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The Electro-Therapeutics of Gynæcology.

PART I.

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THE

ELECTRO-THERAPEUTICS

OF

GYNÆCOLOGY.

BY

AUGUSTIN H. GOELET, M.D.

Fellow of the New York Academy of Medicine and of the New York
Obstetrical Society, Vice-President of the American Electro-Therapeutic
Association, Member of the Société
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the Archives of Gynæcology.
Obstetrics and Pædiatrics.

PART I.

WITH ILLUSTRATIONS.

1892.
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TO

DRS. GEORGES APOSTOLI AND GEORGES GAUTIER

THIS BOOK IS RESPECTFULLY DEDICATED AS A TOKEN OF
APPRECIATION FOR THEIR EARNEST EFFORTS
IN THE ADVANCEMENT OF MEDICAL SCIENCE,

BY THE AUTHOR.

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PREFACE.

The necessity for a practical guide for the application of electricity to gynaecology, according to the modern and most approved methods of Apostoli and his followers, was so forcibly urged upon me by many who have read my various contributions to the journals that I was persuaded to undertake the task, the outcome of which is the present work. The numerous claims upon my time by an active practice, as well as my editorial duties, have rendered the task particularly laborious, and I trust my critics will make due allowance for shortcomings, the existence of which I fully realize.

It has been my aim to simplify the electro-physics so that it can be understood by anyone, no matter how limited his previous knowledge of the subject may be, at the risk of its being considered elementary, knowing that this is one of the stumbling-blocks in the path of the physician or student who desires to acquire the information necessary to intelligently utilize this agent. This chapter has, therefore, been made short, containing only just what is actually necessary, and leaving the special physics of the different currents to be considered in the separate chapters devoted to each. By this arrangement, it is believed much confusion has been avoided, and a clearer appreciation of the different qualities of the several electrical currents will be facilitated. No attempt has been made to make this part of the work scientific, but rather to make it practical for beginners.

The chapter on apparatus contains a description of only such instruments as I have had a personal acquaintance with, either directly or indirectly, which explains why those of my own design predominate. There has been no intentional exclusion of others which may possess equal advantages. The same may be said of the battery apparatus mentioned. I have strenuously avoided mention of any that have not been personally tested and found to be satisfactory, believing that in so doing a great service will be rendered in the selection of satisfactory apparatus. If nothing more has been accomplished, the physician has, at least, been furnished with sufficient information to enable him to decide what is essential without depending upon the advice of the manufacturer, which is not always disinterested.

In the part devoted to electro-therapeutics, I have endeavored to present succintly an outline of a personal clinical experience, which, I must say, has been abundantly satisfactory. So far as the teachings of Apostoli extend and were found satisfactory they have been adhered to, though I have not hesitated to modify and alter his methods to meet the requirements of my own clientele. It must not, therefore, be thought that the treatment herein detailed is strictly in accord with his views in every particular. It is rather a description of methods which I have found successful. I have hesitated to attach any claim to methods which may be original, but in a spirit of fairness have given others due credit for what they have done. The application of the agent has been adapted upon a rational basis to meet the clinical indications, and the technique is presented in minute detail so it can be applied by anyone familiar with gynæcological diagnosis and manipulations.

In confining the text to the subject under consideration, I would not be misunderstood as advocating the electrical treatment to the exclusion of other measures and remedies of unquestioned value. When it has been possible, without too great a digression, this has been distinctly stated in the text, and where it has been omitted there has been sufficient reason for doing so. It would be inappropriate in a work of this kind to follow a course other than that pursued.

If my efforts to awaken a proper appreciation of the value of the faradic current and extend its use in gynæcology are successful I shall feel that my labor has not been in vain.

AUGUSTIN H. GOELET, M.D.

351 West 57th Street,
New York, January 23d, 1892.

PART I.

ELECTRO-PHYSICS

AND

ELECTRO-PHYSIOLOGY.

CHAPTER I.

ELECTRO-PHYSICS.

Electricity is one of the natural forces like heat and light, possessed of a truly wonderful power and action, though invisible. It is not unlike the other forms of energy, and is not more mysterious, but less understood. In order to render its conception lucid, compare it with them and see in how many respects they resemble each other; for instance, heat has its conductors and nonconductors, the same being true of light and electricity; they all exist in a natural state in the universe, but require a separate known force, or power for their artificial production; alike they have motion and are capable of producing motion. Though invisible, electricity is capable of manifesting itself by the effect it produces when set in motion. A current of electricity flowing through a wire will heat it, the amount of heat depending upon the strength of the current and the resistance it encounters; or, if the current is passed through a liquid, the liquid is decomposed by it. It also manifests itself by attraction and repulsion, violent commotions, etc. Electricity may be produced by friction, induction or chemical action, and according to the mode of its production, exhibits a different arrangement of its two qualities *pressure* and *volume*.

To arrive at a tangible conception of this energy in motion, it is necessary to appreciate what influences and retards its progress. It is set in motion by a certain amount of pressure, so to speak, or power, which will be sufficient to send it along its course through a wire or other form of conductor back to its source. This pressure, or power, by virtue of which the electric current circulates, is designated *electro-motive force*, and may be compared to the pressure of steam necessary to set in motion the driving wheels of an engine.

The pressure of this electro-motive force is measured by an unit called the volt, just as the pressure of steam is measured by the pound. We say we have so many volts pressure of electricity, just as we say we have so many pounds pressure of steam.

The Volt.—There is no standard which gives exactly one volt of electro-motive force. The Daniel's standard cell comes nearer than any other, but its electro-motive force is one-twelfth greater than one volt—1.079 volts. A volt is the electro-motive force necessary to produce one ampere of current through a resistance of one ohm.

The Ohm.—The resistance which the current encounters in its passage is measured by an unit called the ohm, and must be overcome by an excess of electro-motive force or else there will be no circulation or current. Just as there must be enough pressure of steam to overcome the weight of the engine and the resistance of the load before there can be any motion. The standard ohm was fixed by the Electrical Congress held in Paris in 1884, and is equal to the resistance of a column of pure mercury one square millimetre on cross section, 1.06 metre in height, at the temperature of melting ice.* It is called the *legal ohm.* Prior to this time the unit in universal use was that of the British Association. It is sometimes designated the B. A. unit. The legal ohm is equivalent to 1.0112 B. A. units. One B. A. unit equals 0.9889 legal ohm.

The excess of the electro-motive force over that necessary to overcome the resistance constitutes the current; hence it is said, *the current is equal to the electro-motive force divided by the resistance,* which is the law of Ohm, after whom the unit of resistance is named. This is frequently expressed in the algebraic formula $C = \frac{E}{R}$, equivalent to, $\text{current} = \frac{\text{electro-motive force.}}{\text{resistance.}}$ Given any two of these quantities the other may be determined by transposition of the same rule; for instance, *the electro-motive force is equal to the current, multiplied by the resistance* ($E = C \times R$); or, *the resistance is equal to the electro-motive force divided by the current,* $\left(R = \frac{E}{C}\right)$

---

*46.25 metres of pure copper wire, one millimetre in diameter, has a resistance of one ohm.

The Ampere.—The strength of the current is measured by an unit called the ampere. An ampere is that strength of current furnished by an electro-motive force of one volt in a circuit, the total resistance of which is one ohm. Its standard value is represented by that current which will deposit 1.118 milligrammes of silver in a second of time, or decompose .00009324 gramme of water per second. Since the structures of the body could not tolerate a current of an ampere, for medical purposes it is divided by one thousand, and each thousandth is designated a milliampere.* The milliampere, then, is the medical unit of measure of the volume, or strength of the current circulating between the poles outside of the battery, or in other words, the intensity of the current; and it must be understood that it in no way represents the quantity.

This measure of the strength of the current is frequently, though incorrectly, referred to as the dose or amount of the current administered, whereas, it is in reality only a record of the intensity. or current strength, just as we would refer to a 2 per cent or 10 per cent solution of a drug, or a solution of so many grains to the ounce, which would in no way indicate the quantity of the drug employed in any given case unless the amount of such solution used was designated. The milliampere, then, is the unit of measurement of the current strength, which expression is synonymous with what the French call intensity, and the milliampere meter is the guage for its registration.

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*The ampere was called so after a Frenchman whose name was Ampere; hence, in abbreviating the medical unit in writing, it would be correct to write m. or m. a. but not m. p.

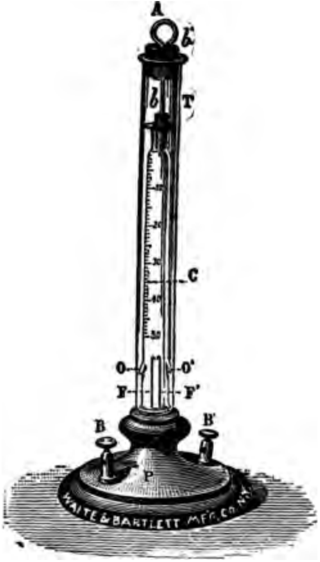

Fig. 1.—Coulomb Meter.

Coulomb and Coulomb Meter.—In order to measure the amount of electricity employed at any given administration, when this is desirable, it becomes necessary to employ an instrument called the coulomb meter, which registers by a scale divided into units designated coulombs, in which a volume of water, confined in an inverted tube closed at the top, is decomposed by having passed through it the electric current employed. The product of this decomposition is collected in the form of oxygen and hydrogen gases in the upper part of the tube, displacing the water into an outer tube surrounding it. The register being arranged from above downwards the surface of the water marks the amount of displacement, which is in proportion to the decomposition, that being proportionate to the amount of the current used. It is, of course, necessary that there should be a break, or separation, in the wire, which passes through the water so that a volume of water will be interposed in the circuit.

The Watt.—This brings us to the consideration of electric energy, and the method of recording it. We have said that the electro-motive force of the battery (or its energy) is measured by an unit, called a volt, and the current flowing between the poles by one called the ampere. The total electric energy, is a combination of the voltage of the electro-motive force of the battery (or cell) with the amperage of the current flowing between the poles external to it. The term watt is used to express this combination of volt-ampere, and is obtained by multiplying the volts of pressure by the amperes of current, from any battery or other electric machine employed for producing a current. For the sake of comparison, to better appreciate the extent of this electric energy, it may be converted into horse power, the unit employed for calculating the energy of steam, since it is estimated that 746 watts are equal to 1 horse power; one watt is then equal to $\frac{1}{746}$ of a horse power. Therefore, in order to estimate the electric energy of a current of electricity, so it can be understood, the volts of pressure or electro-motive force are multiplied by the amperes of current strength, and the product in watts is divided by 746, the result representing the amount in horse power. Hence,

$$\text{H. P.} = \frac{\text{volts} \times \text{amperes}}{746}, \text{ or } \frac{E \times C}{746} = \text{H. P.}$$

It will be seen that these units of measurement bear a definite relation to the units employed in recording other forms of energy.

It will be useless to burden the reader with a definition of the other units of which he may have become cognizant, in reading early works on electricity, such as the dyne, weber, and farad, since they are absolute units for the measurement of the quantity of electricity passing in a unit of time, and are now obsolete.

Conduction.—It must be understood that different substances differ in their capacity for conveying the electric current, and it would be well to know the relative conductability of most ordinary substances, which may be arranged as follows:

CONDUCTORS.	POOR-CONDUCTORS OR INSULATORS.
Metals.	Rubber in its various forms.
Charcoal.	Silk.
Graphite.	Glass.
Acids.	Wax.
Water, etc.	Sulphur.
	Resins.
	Shellac, etc.

The metals possess varying degrees of conductability, some conveying the current easily while others offer a greater resistance to its passage. This difference can only be calculated approximately. For the sake of comparison the following table has been arranged, naming silver as a basis, fixed at 100:*

Silver, 100.
Copper, (pure) 99.9.
Copper, (ordinary) 40 to 70.
Gold, 78.
Zinc, 29.
Brass, 20.
Steel, 16.
Iron, 15.
German Silver, 12 to 15.
Tin, 12.4.
Lead, 8.3.
Platinum, 6.9.
Mercury, 1.6.

Attention is called to the fact that silver and copper are the best conductors, which explains why copper wire is utilized so often for connections of batteries and for conducting wires. It will be noticed that iron is low in the scale, which makes it, in the form of wire, an undesirable and unsatisfactory conductor for most purposes. German silver and platinum, it will be observed, stand so low in the scale, that they may be looked upon in the nature of resisting media, a fact which is made use of to advantage, as will be seen further on.

---

*This arrangement is made by Latimer Clark; the estimate being made at a temperature of 32° F.

It is a well-known law of electro-physics, that a large wire is a better conductor than a small wire of the same metal. Likewise, that the resistance to the current is in ratio to its length, or, in other words, there is more resistance to the current in a wire 500 yards long than in one the same size of 100 yards in length. This has led to the comparison of electricity circulating through a wire with water flowing through a tube, since their behavior is somewhat identical. For instance, a greater volume or quantity of water will flow through a large tube, there being less resistance (if the pressure and inclination is the same) than will flow through a smaller tube, for in the latter case the resistance is greater. In this connection, it would be well to comprehend what is meant by the expression difference of potential, which is used to denote a difference in balance or equilibrium, or what is known in hydraulics as a difference of level.

Potential.—This term can be best appreciated by comparing it with electro-motive force, a term with which it is often (though incorrectly) used synonymously. Potential and electro-motive force (says one author) are really only different ways of regarding the same agency, since both are the cause of motion. But the one, potential, refers to something devoid of motion, though capable of producing motion; while the other (electro-motive force) refers to the motion itself; or in other words, *the one is a motionless force, while the other is force in motion.* Potential may exist while electro-motive force is still absent, the latter being called into existence only when motion is established. As an illustration, we may take a Leclanché cell, which is inactive when not in use, and which contains an inherent potential, but it possesses no electro-motive force until a current is set in motion by completing the circuit, or until the action is started in the cell. Potential is really a difference in balance or equilibrium which permits the operation of the power known as electro-motive force. For instance, the difference in two weights on either end of a balance causes it to move upon its pivot; this difference is known as potential, which allows the motion. Again the difference in the potential between two tanks of water connected by a tube allows the water to flow from the higher to the lower. In the same way, the difference in potential between the negative and positive elements of a cell, permits the generation of a force (electro-motive force) which causes a flow of current from the higher to the lower potential.

Therefore the electro-motive force is in ratio to the difference in balance or potential between the elements of a cell or between the two sides of the source of the current in other devices for generating a current.

Resistances.—Before proceeding further upon this point, it will be well to understand what constitutes resistance in a battery circuit. There are two kinds of resistance in the circuit of a battery, the *internal* and *external.* The *internal resistance* is that which exists in the cell itself, and the *external* resistance is that external to the cell between the two poles. The internal resistance of a galvanic cell is the obstruction which the current generated at the positive or zinc element encounters in transversing the space between that element and the carbon or negative element, and is subject to variations, according to the construction of the cell and its excitants. This variation, which may range from one ohm to one hundred ohms, is influenced by the size of the elements, the distance between them, and the character of the fluid in which they are immersed; since the nearer they are together, the greater the extent of their surface, and the better the conducting power of the fluid, the less the resistance. The external resistance, or that encountered by the current between the poles external to the cell, depends upon the length and diameter of the conductors, the material of which they are composed, and the character of the connections. This resistance should be taken into account and added to that of the tissues which we expect the current to traverse, if we wish to be accurate, though it is ordinarily disregarded, being usually less than ten ohms, while the resistance of the human body will vary from 600 to 18,000 ohms; the average being not much above 2,500 to 3,500 ohms.

Electric Energy of a Cell and Combination of Cells.— Much unnecessary confusion appears to exist upon the subject of the electric energy of a cell and combination of cells. The size of a cell bears no relation to its electro-motive force, which depends upon the difference of potential of the cell elements; hence a small cell will give as high an electro-motive force as a large one having similar elements. A large cell will, however, outlast a small one, *i. e.*, will do more work, and in this respect a galvanic cell is comparable to a steam boiler. A small boiler may be able to furnish the same pressure of steam as a larger one, but the latter is capable of performing more work; and, similarly, a large cell, with correspondingly large elements, will give a greater volume of current, and will be capable of exerting more chemical action, though it will have no greater power to overcome resistance.

It must be understood that one cell will give the same strength of current on short circuit (*i. e.*, without external resistance) as twenty or more cells will give under a similar condition. That is, multiplying the number of these cells in series does not increase the current, though it does augment the electro-motive force, which is readily explained, though apparently inconsistent. The fact is, that while we multiply the electro-motive force, we, at the same time, multiply the resistance in the same ratio, and the result or amperage must be the same, since *the current is always equal to the electro-motive force divided by the resistance* (ohm's law). We may take, for illustration, the Leclanché cell, as being the one (in some one of its modifications) most generally used for medical purposes. It has an electro-motive force of about one and a half (1.5) volts, and an internal resistance of one ohm, and will give on short circuit one and a half (1.5) amperes $\left\{ \frac{1.5 \text{ volts}}{1 \quad \text{ohm}} = 1.5 \text{ amperes.}\right)$ Now if twenty of these cells are coupled together in series (*i. e.*, the zinc of one cell to the carbon of the other throughout the series) we have twenty times one and a half (1.5) volts, which gives us thirty volts, but, at the same time we have multiplied the internal resistance twenty times also, and 30 volts divided by 20 ohms gives 1.5 amperes $\left\{ \frac{30 \text{ volts}}{20 \text{ ohms}} = 1.5 \text{ amperes.}\right)$

Although twenty cells coupled together in series will give no greater strength of current on short circuit than one cell, twenty cells will be able to force the same strength of current through twenty ohms external resistance that one cell will through one ohm.

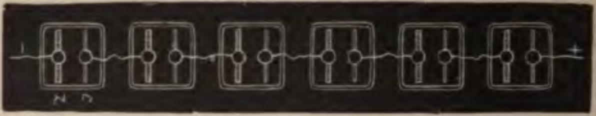

Fig. 2 —CELLS CONNECTED FOR INCREASING THE ELECTRO-MOTIVE FORCE.

This method of connecting together cells is a combination for securing the maximum electro-motive force from a battery, and is known as a compound circuit, or arrangement in series. The current strength is not increased; but it will be understood that since this combination increases the electro-motive force of a battery, it will be capable of overcoming a greater external resistance.

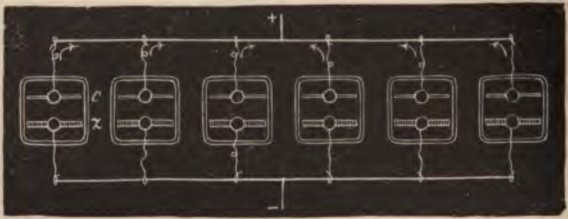

Fig. 3.—CELLS CONNECTED FOR INCREASING THE CURRENT STRENGTH.

In order to obtain the maximum current strength of a battery, an arrangement of the cells known as a simple circuit is made, in which all the zincs are connected together on one side and all the carbons on the other.

In this way the internal resistance is diminished, since the current has to pass from the combined zincs to the combined carbons inside the cells only once. An explanation of this may be had by considering the fact that such an arrangement practically converts the battery into one cell of very large elements; and, while the electro-motive force is that of one cell, the current strength is increased by reason of the lessened internal resistance. It will thus be seen that when the cells of a battery are connected in series, the electro-motive force of this battery will be equal to the sum total of the respective electromotive forces of the cells which compose it, and that when the cells are connected in parallel the electromotive force of the entire battery is only equal to that of any one cell, while its current strength is at a maximum, chiefly owing to the diminished resistance in the interior of the cells.

Conditions Constituting a Satisfactory Cell and Method of Testing Cells.—The cell should be inexpensive, though the materials used in its construction should be pure; it should furnish a high electromotive force, and have a low and constant internal resistance. It should have no action when not in use, should polarize (*i. e.*, lose its strength under use) very slowly, and should depolarize (recover its energy) or recuperate very rapidly under rest.*

---

*The polarization of a cell is the falling off of its electric energy due to the collection of hydrogen on the surface of the

To test the quality of a cell, in the absence of an ampere meter (or am-meter), connect both poles with the milliampere meter, interposing enough resistance, in the form of a coil of copper wire for instance, with it in the circuit, so as to allow the strength of the current to be registered on the scale of the milliampere meter. Note the strength of the current it gives through this resistance. Now short circuit the cell (connect the zinc and carbon elements by a short wire with nothing else in the circuit) and leave it so for an hour, then test it again through the same resistance and note how much it has lost. Remove the connections from the cell and set it aside to rest, testing it at intervals to see how rapidly it recuperates. In twenty-four hours a good cell will completely regain its energy. Some cells will register little or nothing after being short circuited for an hour, and never regain their energy completely. Others are destroyed by being short circuited and never recover. Such cells are not suitable for gynaecological work where low resistances are encountered, and are only fit for work on the external surface of the body where they are always used through high resistances. Why this is so is obvious, since it has been shown that short circuiting a cell rapidly diminishes the energy of any cell and destroys a poor one ; therefore to use a poor cell through low

---

carbon plate and oxygen on the zinc, setting up a counter current in the cell and increasing the internal resistance.

resistances consumes its energy much more rapidly than using it through high resistances. The same is, of course, true of a good cell but it rapidly regains its energy under rest.

The Different Kinds of Currents.—The *galvanic*, *faradic* and *static* currents have been so named for the sake of distinction and not because they are different entities. Their difference is only one of quality depending upon a relationship of *pressure*, and *volume.* Under a like condition of such relationship they are capable of exerting a similar action in every respect. As utilized, however, there is a great difference in the arrangement of these two qualities,—pressure and volume,—which allows a marked difference in their action and effect, and consequently they are entitled to rank as separate varieties of the same agent or energy.

The galvanic current is possessed of a greater volume and less electro-motive force (pressure), as compared with the faradic and static currents, which latter, though possessing a high degree of electro-motive force, are endowed with very small volume. The galvanic is a continuous current flowing in one direction, while the faradic is necessarily intermittent and is constantly alternating from one pole to the other. The static is likewise an intermittent current, but may be continuous. The galvanic current, because of its volume, is capable of producing chemical decomposition in the tissues of the human body which it is made to traverse; but, by reason of the deficiency in volume mainly, the other two currents exert little or no chemical action, and the effect which they produce is chiefly mechanical, though at the same time physiological. It is possible, however, by commutating the faradic current and causing it to flow in one direction, to render it capable of exerting the same chemical decomposition as that produced by a galvanic current. The static current is likewise capable of producing to a certain extent, the same result, because it may be continuous and there is a direction to the current flow, and because it is possessed of some volume, though it may be small by comparison, which renders such result possible in a galvanic current. The reader must not allow these statements to confuse him. They are made in order to show that these different currents are not really different things, as the perusal of some of the current literatnre might lead him to suppose, but they are one and the same, differing from each other only by reason of a different combination, so to speak, of the two qualities (pressure and volume) with which they are endowed.

To comprehend these different qualities of the electric current, by the variation of which it is rendered so apparently complex, it may be compared with water circulating through a pipe. If the pipe is large, a larger volume of water can pass through it in a given time than if the pipe is small; in other words, the increased resistance in the smaller pipe prevents the same volume of water flowing, though the velocity and pressure or tension of the stream is increased. It would be possible by reducing the size of the pipe, to so diminish the volume of water passing through it, that the results of which the stream is capable, will be very different. For instance, the stream of greater volume would extinguish a fire, which in this instance may be compared with the chemical results of the galvanic current, while the smaller stream would furnish a quantity of water insufficient for this purpose, though its capabilities in some other respects would be greater; as is the case with the faradic and static currents.

CHAPTER II.

THE GALVANIC CURRENT.

The galvanic or constant current, flows constantly in one direction, and is capable of producing with certainty and uniformity, chemical and nutrient changes in the tissues traversed by it. When a rod of zinc and a rod of carbon are immersed in a dilute solution of sulphuric acid, the zinc is attacked by the acid, hydrogen is evolved, and sulphate of zinc is formed. If now these two rods are made to touch each other above the surface of the solution, or are connected by means of a wire, hydrögen is given off from the surface of the carbon rod instead of from the zinc as before. This rushing of the hydrogen to the carbon or inactive element, is one manifestation of the effort at an equalization of the potentials of the two elements (rods) which are different, the result being the establishment of a flow of current which is called electricity. A comparative illustration will make this clear. If two tanks of water placed at a different level be connected by a tube, the water will flow from the higher to the lower, but nothing takes place until they are connected. The flow will always be from the higher to the lower; so in the galvanic cell, the flow of the current will be constantly in one direction from the higher to the lower potential.

Circulation of the Current of a Galvanic Cell.—

The current starts from the zinc (positive) element where the chemical action takes place, passing through the intervening fluid to the carbon (negative) element, and out of the cell through this element as a conducting medium, thence along a wire or other conductor, back to the zinc element, whence it started. The current as it circulates inside of the cell, *i. e.*, from the positive to the negative element is designated the internal circuit of the battery, and that circulating between these elements or the poles outside of the battery is the external cir-

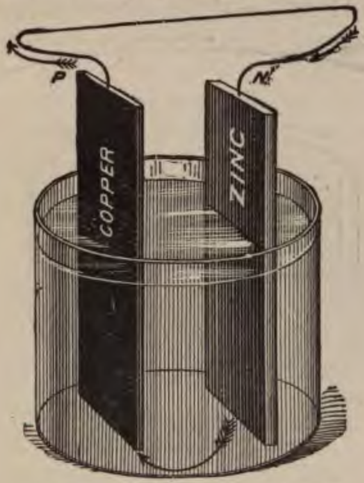

Fig. 4.—Cut showing Circulation of the Current.

cuit. The point where the current emerges from the cell, *i. e.*, at the carbon, though it is the negative element, is called the positive pole of the battery, and where the positive pole re-enters the cell at the zinc is the negative pole. Therefore the carbon, which is the negative element in the cell, is the positive pole of the battery, and the zinc which is the positive element is the negative pole. There need be no confusion on this point.

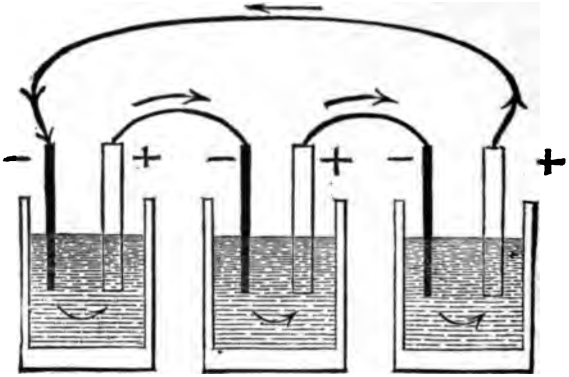

Fig. 5.—Illustrates the Circulation of the Current When Several Cells are Connected in Series.

Varieties of Galvanic Cells.—It will be unnecessary to describe all the varieties of cells in a work of this kind, and the reader is referred to general works on electricity for information of this character. The principal cells in general use to-day are some one of the forms of Leclanché cell, and the red acid (Grenet) cell. The Leclanché cell, which is the only reliable cell suitable for gynæcological purposes, consists of a glass jar half filled with a saturated solution of muriate of ammonia (sal ammoniac, which should be pure), in which is placed a rod of zinc and a porous cup containing gas carbon, and dioxide of manganese to retard polarization. The elements are constantly immersed in the liquid, but no action takes place until the circuit is closed between the zinc and carbon elements outside of the cell. It contains no acid and gives off no unpleasant odor. It is neat and comparatively inexpensive, and will resist the most intense cold without freezing. If the construction of the cell is perfect and the materials used are the best, it will be constant, lasting, and economical, the first cost being the only expense attached to its use for a year or two.

Cabinet batteries are now constructed of some one of the forms of Leclanché cell. Of the numerous forms of this cell, the Axo manufactured by the Leclanché Battery Co., of New York, is the best. It furnishes an electro-motive force of 1.6 volts, which is unusually high, has a constant and low internal resistance, and is closed to prevent evaporation. Its internal resistance increases very slowly under action; in other words, its power diminishes (it polarizes) very slowly, and it recuperates (depolarizes) very rapidly when at rest. A battery composed of these cells may be used constantly for office work for at least one year without requiring any attention, if care is taken to prevent possible short circuiting, by having the switches always turned off, and the conducting cords removed when it is not in use. The zinc when consumed may be renewed as well as the solution when exhausted; but it is not economy to renew the porous cup contents. When the cells become completely exhausted, their power may be restored by cleaning the surface of the porous cups and immersing them in boiling water to remove the hard crystals which form, then placing them one side for several weeks to dry out thoroughly. With the addition of new zincs and fresh solution they may be thus rendered almost equal to new cells.

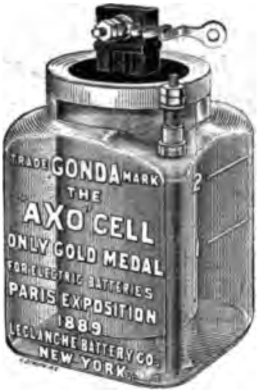

Fig. 6.—"Axo" Cell.
Complete.

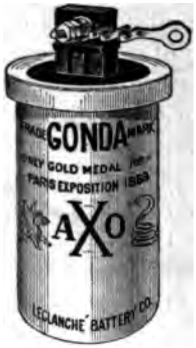

Fig. 6.—"Axo" Cup.
Alone.

In this connection a modification of the Leclanché cell, the Double Cylinder Law cell, manufactured by the Law Telephone Co., of New York should be mentioned. In this cell the solution and zinc are the same as in the other, but the negative element consists of two cylinders of gas carbon arranged so as to expose a large surface to the solution, which reduces the internal resistance, and is supposed to do away with the necessity of using a depolarizing agent like

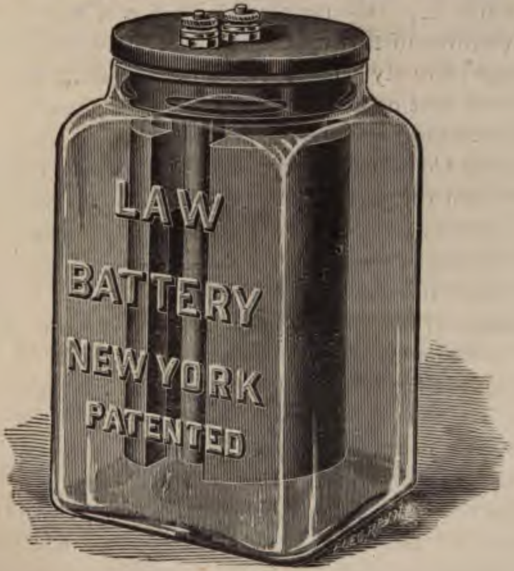

Fig. 7.

the dioxide of manganese in the other cell. The top is securely fastened in position, with a rubber band intervening between it and the mouth of the jar, which effectually prevents evaporation or spilling the solution. The makers claim for it an electro-motive force of 1.5 volts, which is a little high. The average is really a little below this figure. Its cost is double that of the other cell.

The Edison-Lalande cell, made by the Edison Manufacturing Co. of this city, is a form of cell recently introduced for medical use. The elements are zinc and black oxide of copper (CuO). The exciting fluid is a solution of caustic potash. The cell gives an electro-motive force of .7 of a volt and has an internal resistance of only .025 of an ohm. On account of the low electro-motive force, twice the number of cells are required for doing the same work as the Leclanché cell. The capacity of the type (C) used for medical purposes is 50 ampere hours. The manufacturers claim that the current is practically constant during the life-time of the cell. When the cell is exhausted the cost of renewing the elements and fluid is comparatively insignificant, and the cell is as good as new. The original cost is a little more than the Leclanché cell, and as two are required to do the same work, the cost of a battery composed of these cells is more than double.

Portable batteries are usually supplied with the red acid (Grenet) cells, which are considered convenient for transportation from house to house. They are not entirely satisfactory on account of the destructive nature of the fluid, which spills out unless handled with extreme care. The cells consist of small glass or hard rubber cups containing a dilute solution of sulphuric acid (1 part sulphuric acid and 16 parts water, to which is added finely powdered bichromate of potash 2 parts, and bisulphate of mercury 15 grains). The elements are plates of zinc and gas carbon of equal size, which are immersed in the fluid when in use, and removed immediately afterwards. The strength of a battery of this kind deteriorates very rapidly under constant use, but the strength can be brought up again by renewing the fluid. The surface of the zincs should be kept clean and amalgamated.* When working with this form of battery, the meter should be kept constantly under observation, as it will often take a minute or two to reach the maximum strength of current from a given number of cells, owing to the deposit which forms on the surface of the zinc, when not in use, preventing immediate action; and when the maximum is reached, the strength of the current will often diminish rapidly, because of the deterioration in the quality of the fluid under use. The needle of the meter will deflect slowly at first, then suddenly showing a rapid increase in the strength of the current, and later it may drop back slowly to a point which might be insufficient to meet the requirements of the case in hand. This unevenness of the current is very unpleasant to the patient besides being unsatisfactory in its effect. It is, however, the most reliable portable battery for furnishing the strong currents sometimes necessary for gynæcological work, and if properly constructed with hydrostat for sealing the cups when not in use, one of the most objectionable features is overcome. It should never be used without a rheostat for regulating the current, as the sudden increase of the current when turned on, a cell at a time, is most objectionable in this form of battery, because the electro-motive force of the cell is high. These objections have led some writers to declare that a battery composed of Leclanché cells is the only one suitable for therapeutic purposes.

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*To amalgamate the zincs, immerse them in a dilute solution of sulphuric acid to cleanse the surface, then rub them over with metallic mercury; or immerse them for a short time in a solution of bisulphate of mercury to which a little acid is added, then rub them off. Be careful to prevent the screw attachment on top of the zinc from coming in contact with the acid solution.

Gaiffe, of Paris, makes a very convenient and satisfactory portable battery of small cells, in which a solution of bisulphate of mercury is used for the acting fluid. The cells are constructed so as to avoid spilling the solution. A battery of sixty cells is not inconveniently large.

A very convenient form of the Leclanché cell for portable batteries, is known as the Moist Leclanché Disque Battery, manufactured by J. C. Vetter & Co., of New York. This cell consists of a vessel of zinc, instead of glass, varnished for protection on the outer surface, the inner surface being left free for action. The carbon disc in the centre is surrounded by broken carbon and dioxide of manganese in a porous cup made of paper. The muriate of ammonia made into a paste with water and plaster of paris is placed between this porous cup and the zinc walls of the cell. The cup is sealed at the top to prevent evaporation, an aperture being left to renew the moisture and allow the escape of gas. This is a very neat and convenient cell for portable batteries and is made in several sizes, but it must not be expected to do as much constant work as the other form of Leclanché cell. The makers claim for it an electro-motive force of 1.58 volts with an internal resistance of .54 ohms. Those tested were when fresh equal to the other form of Leclanché cell, but they were not so lasting. A portable faradic ap-

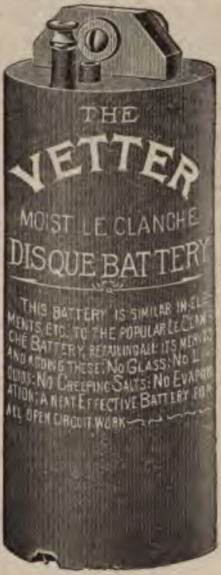
THE
VETTER
MOIST LE CLANCHE
DISQUE BATTERY
THIS BATTERY IS SIMILAR IN ELE-
MENTS, ETC. TO THE POPULAR LE CLAN-
CHE BATTERY, RETAINING ALL ITS MERITS
AND ADDING THESE; NO GLASS: NO LI-
QUIDS: NO CREEPING SALTS: NO EVAPOR-
ATION; A NEAT EFFECTIVE BATTERY FOR
ALL OPEN CIRCUIT WORK

Fig. 8.

paratus operated by these cells has proved very efficient. Of the various forms of so called dry cells this is probably the best. It can be placed in any position, even upside down without injury, as there is no fluid to spill or leak out. It is one-half the size and one-half the weight of the Leclanché cell.

The chloride of silver cell, though very suitable for portable batteries, is unsatisfactory for gynæcological work, being inconstant, and insufficient for electrolysis. It is ruined if short circuited and becomes rapidly exhausted if used through low resistances. Low resistances will exhaust any cell much sooner than high resistances, and for this reason all cells are not suitable for gynæcological work. The low resistances encountered in this class of work cause the chloride of silver cell to become polarized and it does not regain its energy. But for use upon the external surface of the body, where high resistances are encountered, and for operating a faradic coil, it has been found satisfactory, and if properly cared for it will last for some time.

Where it is necessary to use a galvanic battery at the patient's house, it is better to have the patient hire or buy a red acid battery, unless the physician has one at his disposal for this purpose, and keep it there until the work is completed.

Sources of Electrical Supply Other than the Galvanic Cell.—Besides the battery of galvanic cells, the current may be obtained either from an individual dynamo-electric generator or from the electric-light main. The author has had no personal experience with either of these sources of electricity, and prefers the battery of galvanic cells on account of safety. With the others, especially the street main, there are too many chances for dangerous shocks. According to the statements of those who have had experience with it, unbearable pain is produced by the use of the same strength of current that would give no inconvenience from a battery current. It is also claimed that it is too fluctuating for medical purposes. It would, however, prove useful for operating electric motors, for charging storage batteries, and for heating cautery knives and electrodes.

Within the past year Dr. Henry G. Piffard* has introduced an adapter for the Edison current, as obtained from the street, for which he claims perfect satisfaction and safety, having introduced upon the adapter in the circuit a lamp or safety governor, the fibre of which will burn out and cause a break in the circuit when a current strength of five hundred milliamperes is reached. By this arrangement he thinks this current can be employed with perfect safety. As his work is mostly upon the external surface of the body (where the resistance is high), this statement might appear to be correct, though here a break in the circuit, and consequent shock, would not be without pain or an element of considerable danger. For example, in order to produce a current of 500 milliamperes through the resistance of the safety lamp, which is 240 ohms, plus that of the human body, which is about 3,000 ohms, an electro-motive force of 1,620 volts would be necessary, since by Ohm's Law the electro-motive force is equal to the current 500 milliamperes, or half an ampere multiplied by the resistance, 3,240 ohms. (3,240 ohms × .5 ampere is equal to 1,620.0 volts.) The danger of such a current will be readily understood. For gynæcological work it is certainly not safe, and no one should take the chances of submitting the delicate structures sometimes included in the circuit to the shock from such a current. This adapter is described at length in the journal referred to, and is, perhaps, a step towards the future employment of the street current for medical purposes, which from the point of economy and convenience is a desideratum. But some safer adapter must be devised before it can be universally adopted.

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*New York Medical Journal, June 7th, 1890, and June 11th, 1891.

The medical dynamo is undoubtedly the more desirable of these extraneous sources of electricity. The one designed and recently recommended by Dr. Willington Adams, furnished by Reynders & Co., of this city, is probably the best of its kind. It is capable of giving two currents, one having an electromotive force of five volts and furnishing a possible strength of sixty amperes, which would be suitable for cautery and illuminating; the other has an electro-motive force of two hundred volts, with a possible strength of one ampere, suitable for therapeutic

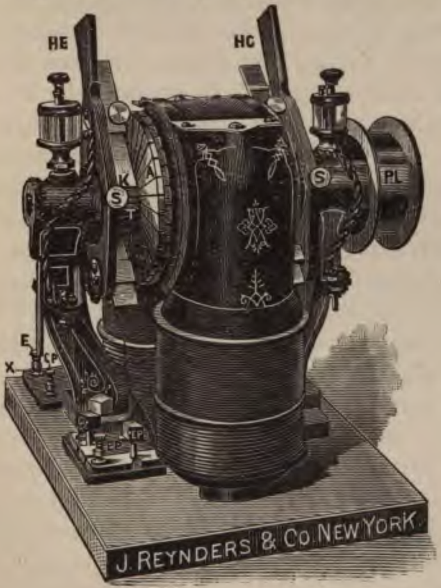

Fig. 9. — Medical Dynamo.

purposes. The one is identical with the current generated by the cautery battery, while the other is similar to a battery of cells arranged in series. The arrangement is such that both of these currents can be utilized at the same time. The current for therapeutic use is equivalent to that produced by a battery of one hundred and forty Leclanché cells. It has an automatic device for preventing the current from reaching a dangerous strength for the patient, or destroying a cautery knive. It is claimed for this machine that it will generate a perfectly steady and reliable current. It can be operated by an electric motor where the street main is at hand, or a gas engine, a water motor, or a one-horse power steam engine. It should run at a uniform speed of 1,800 revolutions per minute. Such a machine possesses many advantages for a specialist in electricity, who has constant use for both kinds of currents which it furnishes, but for the general practitioner, and for gynæcological work, a battery of cells is far more desirable.

The current from a magneto-electric generator, which is strictly an alternating current, is derived from a permanent or an electro-magnet, by revolving in front of it an armature composed of a core of soft iron, wound around with insulated wire. Currents are formed by breaking the lines of magnetic force. For medical purposes this form of current is practically obsolete, since the current is too unsteady as produced by the old machines where hand power was employed. The current may, however, be commutated by means of an automatic polarity changer, and made to flow in one direction when it possesses properties similar to the galvanic current, and is used for electric lighting, electro-plating, etc., being much cheaper than a battery current. It is practically this kind of current which is produced by a medical dynamo, or which is obtained from an electric-light main. From what has been said it will be understood how it can be utilized for medical purposes.

PROPERTIES, ACTION AND APPLICATION OF THE GALVANIC CURRENT.

Electrolysis, or the Chemical Action of the Galvanic Current.—As has been noted, the galvanic current produces chemical changes in organic tissues submitted to its influence, by which a separation into component elements is brought about. In other words, a physiological disturbance of the integrity of the structures is induced by the passage of the current. This phenomenon is termed *electrolysis.* Strictly speaking *electrolysis is the separation (decomposition) into component parts of a compound body in solution by a galvanic current.* It will be understood, therefore, that this process is possible in human tissues because the elements are in a fluid state, and unless this was true, chemical disintegration would not take place. While these changes occur to a certain extent in all the structures included within the sphere through which the current is diffused in its passage from one pole to the other, the action is more marked in the vicinity of the poles.

When animal tissue is submitted directly to the action of the current, oxygen and chlorine are liberated at the positive pole and hydrogen at the negative, by decomposition of the fluid elements of the tissues; acids collect at the positive pole, and alkalies at the negative. The changes resulting from this decomposition are, of course, very different at the two poles. The mineral acids (sulphuric, nitric, phosphoric and hydrochloric) with the chlorine set free in the immediate vicinity of the positive pole produce an action similar to an acid caustic, and there is coagulation of albuminous substances with blanching of the tissues. The result is an increased hardness and density of the surrounding structures, which become dry. The action produced at the negative pole is that of a caustic alkali, and is due chiefly to the concentration there of hydrate of soda, potash, lime and ammonia evolved from the tissues. The mechanical effect of the liberated hydrogen is likewise accountable for some of the effect observed at this pole. An electrical osmosis is set up in the direction of the current from the positive pole to the negative pole, in consequence of which the fluid elements of the tissues are driven to the negative pole and depletion takes place at the positive. This accounts for the liquefying effect of the negative pole and the blanching, hardening, and drying effect at the positive pole.

In speaking of the caustic action of the current, it must be understood that it is produced only at the point of contact of the poles with the tissues when bare or unprotected electrodes are employed, and that it is in proportion to the strength of the current and the duration of its continuance; also that the penetration of this action is controlled in the same manner. The effect upon the tissues in the immediate vicinity of the poles when protected electrodes are employed is not caustic, but is the result of the peculiar chemical exchange referred to above. The action of the current is to be divided into *local, polar* and *interpolar.* The *local action* is generally caustic with high intensities of current, but is not caustic with a moderate strength of the current. The *non-caustic polar action* is that in the immediate vicinity of the poles, and may be concentrated by limiting the area of diffusion in favor of either pole, or increasing the density of the current so as to render the one or the other effect more pronounced. In this way a distinct active pole is created, whereby either a negative or positive electrolytic effect predominates. The interpolar action sets up nutritive changes, the exact nature of which is, as yet, unknown.

Some writers designate the local disintegrating action of the poles electrolysis, and the interpolar effect of the current, catalysis. This division is convenient, though sometimes confusing. Upon this point Amory observes, "Catalysis may mean anything, and is generally used by a writer to express some immaterial or mysterious agency which he himself cannot describe. On this account, though used by many writers as expressing an agency which is familiar to the person using the word, it should not be used in a common sense, because this use tends to mislead the reader."

Therapeutic Properties of the Galvanic Current.—The therapeutic properties of this current are those due to its interpolar action and those due to its polar action. The interpolar effect is probably the result of nutritive and circulatory changes chiefly, but the polar action is of a more pronounced character, and is that upon which we depend mostly for the benefits to be derived from its use. The changes attributable to the polar action are increase or decrease in the capillary circulation depending upon the predominance of the influence exerted by that pole which is made the most active, and the consequent changes of nutrition which would be expected therefrom. It is known that this current has always one direction, from the positive to the negative, and it is to be expected that a direct effect upon the circulation can be induced by its proper application.

Aside from this the nervous system is subservient to the galvanic current. When a nerve is subjected to the influence of the negative pole, its excitability is increased (catelectrotonus) and when subjected to the influence of the positive pole, its excitability is diminished (anelectrotonus). This may be accounted for by the discovery of Humbolt that contact with an alkaline solution increased the excitability of a nerve, and that it was diminished by contact with an acid solution. It is an accepted fact that the negative pole will irritate a hyperæsthetic condition of a nerve track, while the positive will soothe.

There is as marked a difference in the therapeutic properties of the two poles, as the contrast in the chemical result would lead us to anticipate. In a general way, the positive is known as the *coagulating* pole and the negative is the *liquefying*, or *dissolving* pole, and that which promotes absorption. In referring to the polar and interpolar action, it must be understood that in gynæcology the local action is that which takes place at the contact of a bare electrode with the tissues, as where puncture is resorted to, or where it is applied directly to a mucous surface, like the interior of the uterus, with an exposed metallic or carbon surface, and that the polar action includes that in the vicinity of the poles beneath the surface of contact, while the interpolar action is that influence exerted by the current at a greater distance from the active pole, and between the two. According to this division then, the effect of the immediate polar action of the positive pole may be said to be ***anodyne, sedative, anti-congestive, denutritive*** and ***anti-hæmorrhagic*** or ***hæmostatic.*** It relieves congestion and the pain depending upon it. In its local action the effect is only styptic, with a moderate strength of current, and it is a chemical hæmostatic caustic with a greater strength of current. The eschar resulting from the caustic action is firm, dense, dry and retractile.

The polar action of the negative pole is *stimulating*, *congestive*, *derivative* and *alterative*, favoring absorption by liquefying the tissues. In its local action it produces a softening and dissolving effect with a moderate current strength and bare electrode. It has, however, a decided caustic action with a much lower strength of current than the other pole. Both poles, then, have a marked caustic action which differ according to their chemical attributes. They are designated and distinguished by Apostoli as "*positive chemical galvano-caustic*, and *negative chemical galvano-caustic*." Distinction must be made between the chemical caustic action of the galvanic current and what is usually termed galvano-cautery, which is really produced by the actual cautery of a heated platinum wire or the same formed into a knife; an electric current of great quantity obtained by a peculiar arrangement of battery described elsewhere, being employed for the purpose of heating the wire.

The changes attributable to the polar action are due to two things, (1) the changes in the circulation differing with the pole, (2) the fluidifying effect due to the mechanical transference of fluids to the negative pole, producing at the same time, of course, a corresponding depletion with drying effect at the positive.

Undoubtedly an electrolytic action is induced throughout the interpolar sphere, and its influence is by no means unimportant, though obscured by the more pronounced character of the effect produced nearer the active pole. As evidence of the direct therapeutic value of this interpolar influence, consider the beneficial effect produced upon the pelvic organs by passing the current through from the supra-pubic region to the sacrum, both poles being external; and, also, the marked relief afforded in certain chronic joint affections by passing a strong galvanic through from one side to the other.

Application of the Galvanic Current.—No absolute theory of the application of the galvanic current can be constructed, mainly because of the difficulty in the way of an absolutely accurate diagnosis of the definite morbid exchanges in each individual condition. Nevertheless certain rules may be formulated as a guide for its application which are sufficient for practical purposes. It is certain that the current flow is from the positive to the negative pole and that the fluids of the body are conveyed with the current, hence if it is desired to increase the congestion of a part, the negative would be the active pole, and on the contrary, if it is desired to diminish congestion, the positive should be the active pole. The chemical changes described above undoubtedly form an important part of the galvanic action, and deserve special consideration in the application of the current for therapeutic purposes, inasmuch as they differ materially with the pole which is made the most active.

An active pole is created by concentrating the current to a limited area at one pole and diffusing it at the other. When the current is concentrated it is said to be dense, and it exerts more action than when spread out or diffused over a large area; just as water forced through a small tube has more force than when the same pressure compels it to pass through a larger tube; a point made use of frequently in the treatment of pelvic deposits and tumors. Therefore bear in mind the fact in applying the current, that the active pole is to be placed invari-

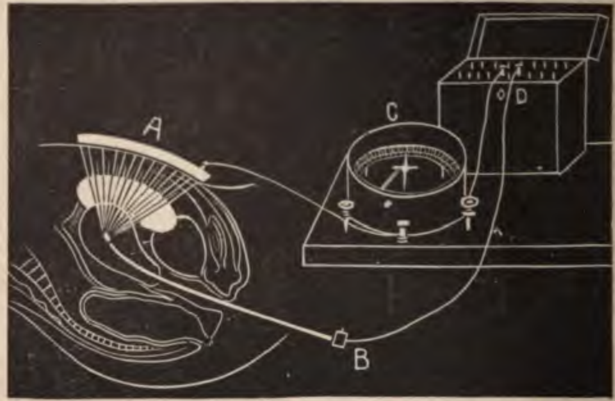

Fig. 10.—A, Diffusing Electrode. B, Electrode in Uterus. White Body represents Tumor. Lines show passing current.

ably, as nearly as possible, directly in contact with the diseased structures to be submitted to its influence, and the external or dispersing pole is to be placed so as to include them directly between the two poles. The location of the inactive pole must obviously be variable and may be placed upon the abdomen, over the sacrum or the lumbar region as best suited for this purpose. The diffusion of the current at the inactive pole is important, not only to bring within the range of the current a tumor or other morbid structure, the size of which exceeds the surface included in the contact of the active pole, so as to comprise the whole or nearly all of a large tumor (see figure 10), but also to render a current of sufficient strength easily tolerated by the integument.

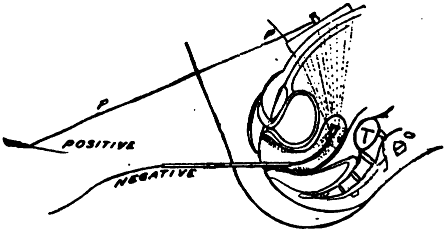

Fig. 11.—Showing Incorrect Position of Electrodes, the Tumor T being Excluded from the Influence of the Current.

It may be as well here to explain that the resistances encountered in gynæcological work are much less than in ordinary applications upon the external surface of the body where both poles are applied to the skin and the size of the electrode is often limited on account of the location, because of the fact that a very large external electrode can be employed upon the skin surface, and because the mucous surface of the vagina, as well as the interior of the uterus, offers very little resistance to the penetration of the current. This makes it clear why it is possible to obtain such apparently enormous intensities of current from a battery with no greater number of cells than is required for ordinary general applications. It must be borne in mind also that the poles are frequently quite near to each other in gynæcological applications, which still farther diminishes the resistance.

By splitting the current up and sending it in different directions from one pole to the other, each route bears an exact numerical relation to the other in the intensity of the current it conveys, provided the resistances encountered by the different routes are the same; just as in the case of several pipes of the same size leading from the same reservoir, if the inclination is the same, will convey an equal volume of water. That is to say two wires, leading from one pole, will each convey to the point of contact exactly the same volume of current, the total of which would be the same as would be conducted by one wire, or each will carry just one half of the current. This can be demonstrated by placing a milliampere meter in both routes at the same time. As will be seen in the treatment of tumors this is made useful in various ways. For instance, when a tumor is so located, or is so large as not to be included when the current is passed from the vagina to the abdomen, or the surface of the integument is too sensitive to bear one electrode, a bifurcated cord is used from one pole of the battery and two external electrodes are used at the same time, one on the abdomen and the other on the back. Again in puncturing a tumor, when a one hundred milliampere current would be too painful to be endured from one needle, five are used and the current split up, or diluted, so as to make each needle convey only twenty milliamperes, which could be readily borne if the needles are not inserted too near each other.

In addition to the action beneath the surface of contact in the vicinity of the active electrode, there is a distinct local action at the point of contact which is intensified or rendered more pronounced by using a bare metallic or carbon electrode. This local action is avoided by covering the electrode with some material like wet absorbent cotton or moistened clay. The local action of both poles is decidedly caustic with a current strength of fifty milliamperes when continued for five minutes or more; the positive pole producing an acid caustic, and the negative an alkaline caustic effect. The severity of this caustic effect and the extent of its penetration is varied by the strength and relative density of the current and the duration of its continuance. Hence, an electrode with a limited surface of contact, by increasing the density of the current, allows a greater degree of cauterization than one of larger surface with the same strength of current, which is a point to be seriously considered in making applications to the uterine canal. It may be well to repeat here that with a moderate strength of current and bare electrode used for a short time, the local action is not caustic with either pole, but is simply styptic and astringent with the positive pole at thirty milliamperes or less, and with the negative at twenty milliamperes or less, it is only liquefying, softening, and dissolving or relaxing.

It will be seen that in consequence of the variety of its action this agent is applicable in many pathological conditions of the pelvic organs; for instance, it can be employed for influencing the blood supply to the uterus or surrounding structures by making the active pole negative, and it is thus useful in amenorrhœa, and for stimulating nutrient changes and a sluggish circulation; and by making the active pole positive the blood supply is diminished—painful conditions and congestion are relieved. By utilizing the chemical action in the vicinity of the poles, hæmorrhage is controlled and chronic inflammatory action in and around the uterus is immediately benefitted by the positive pole, while the negative exerts a liquefying effect upon exudations and promotes absorption. The local caustic action of the two poles may be utilized in many ways; that of the positive for controlling hæmorrhages from the uterine cavity and for the cure of endometritis when associated with a profuse discharge of mucous secretion; the negative caustic being applicable in conditions like sclerosis, and where the discharge is purulent or muco-purulent. The softening and dissolving action of the negative pole with a moderate current strength will be found useful in overcoming stenosis and obstructions in the cervical canal, and for softening and relaxing the indurated angle of a flexed uterus, also in atonic conditions of the uterus and its lining membrane; while the styptic, astringent action of the positive with a moderate strength of the current is useful in mild cases of catarrhal endometritis.

Dr. William J. Morton of this city has recently advanced a theory * which he hopes may serve as a guide to electro-therapeutic administrations. Assuming the natural chemical exchanges which take place in human bodies in health and disease, and the accepted fact that these exchanges produce currents of electricity, as well as heat, Dr. Morton suggests that

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* In a paper read before the first annual meeting of the American Electro-therapeutic Association, of which he is now president.

the physician's applied current shall be caused to flow either in the same direction or contrary to the natural animal current of the disease. If, as is supposed, the animal current is due to the chemical nutritional processes which underlie the disease, he claims that a current opposed to this first current would oppose the malnutrition which produced it, whereas a current in the same direction would increase the malnutrition or perverted chemical exchanges. This is the simple fundamental proposition which, so far as the effect of current upon current is concerned, may be demonstrated by a simple laboratory experiment with ordinary voltaic cells.

The theory involves two important data, first, an intimate knowledge of pathological processes, and second, a knowledge of the direction of the current set up by the diseased process.

As to the first of these data or guides, Dr. Morton suggests that until some other clearer pathological basis is utilizable, it may be assumed that disease is a perversion of metabolic exchanges, and that in a given pathological process the metabolic exchanges are either over active or under active. Granting this pathological view, it is an electro-physical fact that the positive pole or direction of current will increase over active metabolism while the negative will arrest the same.

On the other hand, if the chemical exchanges which constitute the perverted metabolism are under active, the positive pole or current would excite the under active processes, while the negative pole would still further add to the under activity.

In short, in over activity the negative pole palliates or cures, while in under activity the positive pole palliates or cures.

As to the second of the datà given, that of the direction of the natural animal current, this is easily determined by the aid of a delicate galvanometer and the non-polarizable electrodes of Dubois-Reymond. Dr. Morton is now making further tests to determine the electric polarity of given diseases. Having ascertained this polarity he applies a counter or a similar current as the case demands. He does not, as yet, advance these ideas as constituting a fixed procedure, but merely as suggestive of the possibility of attaining such an end, and thus arriving at a greater degree of certainty in electro-therapeutics than is now practiced.

It will be noted that the theory is founded upon a purely chemical basis of disease and therefore does not call in question the accepted fact that the positive pole is sedative to nerve irritability while the negative pole is stimulating. This is a physiological reaction which Dr. Morton reconciles to his theory by arguments which are beyond the scope of this brief resumé.

The theory has its obvious applications both to chemical galvano-caustic and galvano-puncture operations as well as to the ordinary percutaneous administrations, and if it proves to be well founded, will prove to be a most important guide in making a choice between a positive or a negative pole.

We have not yet referred to the germicidal and antiseptic action of the current which is of great import. The researches of Apostoli and Laguerrier have proven beyond dispute that the galvanic current possesses this quality in a marked degree, but that this action is exerted only in the vicinity of the positive pole with a current strength of more than fifty milliamperes, and that it is independent of the thermal influence, depending solely upon the influence exerted by the presence of the oxygen and chlorine liberated there. The conclusions deduced from their experiments are, that a continuous current flow of 50 to 300 milliamperes *sui generis* has no germicidal action, but the positive polar action is positively germicidal with a current strength of from 100 to 150 milliamperes employed for a period of five minutes or more. Their experiments with pus and staphylococcus demonstrated that the oxygen liberated at the positive pole is the active destructive agent. Apostoli formulates the conclusion that, "*A small electric dose, applied even for a long time, never produces upon living organized tissues the same effect as a larger dose applied for a short time.*" This is an important point, and is a direct refutation of the claims of certain timid operators, who have proclaimed in favor of small doses continued for a longer time as being safer and equally beneficial for all conditions.

In this connection it may be well to mention the cataphoretic action of electricity or anodal diffusion, as it has been termed by Dr. Frederick Peterson, and its therapeutic value. By these terms it is intended to designate the power of a galvanic current to carry along with it, in flowing from the positive to the negative pole, through a membrane or the skin, many drugs in solution. In this manner anæsthesia may be produced with solutions of cocaine, morphia, aconite, or chloroform, and other drugs may be introduced into the circulation for medication of local lesions, such as tumors, rheumatic gout, and other swellings. Recently Dr. Hunter McGuire has employed tincture of iodine by means of a vaginal electrode for its effect upon fibroid tissue in the pelvis, and has reported some success. He employs an electrode especially constructed for holding the iodine and uses only ten milliamperes of current for ten or twenty minutes at each sitting. Acting upon this suggestion, the author has employed a solution of ergot in the same manner, but as yet sufficient time has not elapsed to form any conclusion as to the result to be obtained. For two years or more he has used cocaine in this manner for certain deep-seated pain in the pelvis, with marked benefit. These points are mentioned only to suggest further experimentation in this direction, which it is to be hoped will be productive of practical results.

Most experimenters in this direction have employed the drug only upon the positive pole, but Dr. W. J. Morton, in a contribution upon this subject, advocates placing the solution on both poles, which removes the doubt and uncertainty of the question as to which pole would be the most appropriate for any certain agent, as raised by some writers, and positively secures the effect desired. He states that some substances travel only from the negative to the positive pole, as for instance bromide of barium. Dr. Morton has also described a new method of cataphoresis which consists in rendering the part to be treated, where practicable, bloodless, by means of an Esmarch's bandage or rubber rings of various sizes. By means of this anæmic method the medicine employed, or some electrolytic modification of it, coming into direct contact with the affected tissue, is not immediately washed away by the blood stream. The method is especially applicable to the treatment of rheumatic and gouty joints by lithium or other salts; and wherever applicable, reduces cataphoric medication to a more exact and a more efficacious procedure.*

Gautier† of Paris has recently furnished a practical contribution upon electro-chemical treatment in another direction. He has demonstrated the fact that a solution of iodide of potassium applied upon the electrode, increases the germicidal action of the poles, which fact he has taken advantage of and applied successfully in the treatment of certain ulcerative processes such as venereal ulcers, lupus, and also for keloid growths, cysts, hydrocele, etc. He has employed it extensively in the treatment of ulceration of the cervix, catarrhal and purulent endometritis, salpingitis, and for specific urethritis in the female with marked success.

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*New York Medical Journal, April 25, 1891.

†Revue Internationale d'Électrothérapie for June, 1891—a translation of which is to be found in the Archives of Gynæcology, etc., for August 1891.

In the decomposition of the iodide of potassium by the current, oxygen and iodine are liberated at the positive pole, and hydrogen and potassium go to the negative. The germicidal polar action is thus increased with a moderate strength of current.

He uses a platinum sound or applicator wrapped with a light layer of absorbent cotton which is dipped in a solution of iodide of potassium (one to ten). In urethritis he connects this with the positive pole and employs an intensity of twenty-five milliamperes for ten minutes. In the cervical canal he uses the negative pole with fifty milliamperes of current for the same length of time. His results have been excellent. The author can attest the value of this treatment in ulcerations of the cervix and in endometritis. For the purpose he has had constructed a flat platinum applicator which can be attached to the universal handle shown in fig. 45 in the chapter on apparatus.

CHAPTER III.

THE FARADIC CURRENT.

Two factors are involved in the production of the faradic current (sometimes called the induced or interrupted current): (1), The battery current from the generating cell, and (2), a magnetic influence exerted by a temporary magnet within the coil (helix) in the form of a bundle of soft iron rods (the core), which is converted into an electric-magnet when the current circulates in the coil of wire surrounding it. It is customary to speak of two currents in connection with the faradic apparatus, the primary and secondary, though the latter is the one mostly employed, the primary being seldom used.* It is necessary, however, to understand both, and how they are produced.

The primary current is derived from the helix or coil which immediately surrounds the core or bundle of iron rods in the primary coil. The current from the generating cell starts from the positive pole of the cell, passes through the attachment called the interrupter (vibrator or current breaker), thence through the coil immediately surrounding the core, and back to the negative pole of the cell.

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* Dr. Massey prefers the primary current for many purposes, and claims good effect from it in certain soft myomas in producing contraction of the growth.

The interrupter is essential, for without it the current would be inappreciable and would have no effect. It is an automatic device, the interruptions being produced in the following manner, viz.: the hammer on a level with and near the end of the core, is attached to a spring resting upon a point which completes the circuit through the coil surrounding the core when it is at rest. As soon as the current is started from the generating cell, it immediately circulates in this coil, magnetising the core, the hammer is attracted towards the core by its magnetic influence, the circuit is broken at the point upon which the spring rests, the current ceases to flow through the coil, and the core loses its magnetic influence allowing the hammer to drop back into position, when the circuit is again completed and the same thing is repeated.

Primary Current.—It must not be supposed that the primary current as derived from the battery for use upon the patient comes directly from the generating cell, or that it may be utilized as a galvanic current. It is true that the battery current from the generating cell is a galvanic current, being derived from a galvanic cell, but its electro-motive force is too feeble for any appreciable action through the resistances of the human body, independent of the inductive influence of the core. The electro-motive force of one cell is, of course, insufficient to overcome the resistance of the human body, which is much greater than the resistance offered by the coil; hence the current circulates by preference through the coil. To illustrate this, connect the two binding posts of the battery by means of a short wire which offers less resistance than the coil, then start the current from the cell. The vibrator will not move, showing that the current has taken the course of least resistance, instead of passing through the coil. (The ordinary conducting cord will not do for this experiment, but a short piece of stout copper wire should be used. The ordinary rheophore or conducting cord composed of several strands of very fine copper wire offers more resistance than most primary coils.) If on the contrary, a greater resistance, like the human tissues, be interposed in the circuit between the primary binding posts, the course of the current from the generating cell will be through the coil, which offers less resistance.

It is, therefore, an induced current, produced by the magnetized iron core, which circulates through the electrodes and the patient between the primary binding posts, when the circuit is broken at the vibrator. It is, then, only when the circuit is broken that the influence is transferred through the primary binding posts of the battery, and thence through the conducting cords to the electrodes and the patient. At the moment of contact of the vibrator spring, or when the circuit is made, the current circulates in the coil, and when it is broken, the extra or induced current discharges through the primary binding posts. The discharge of this extra or induced current, through this avenue which has been afforded for its escape, constitutes the primary current. This same extra or induced current may be transferred to another coil surrounding the primary, and is then known as the secondary current.

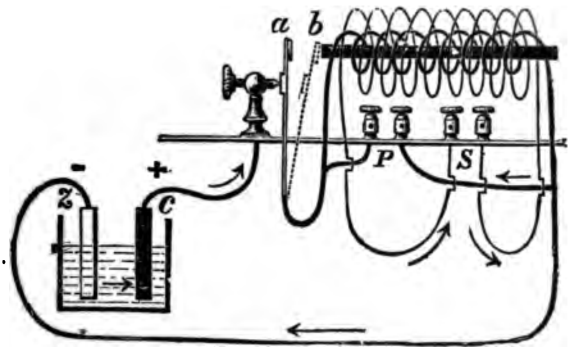

Fig. 12.

As seen in the cut, the primary coil is tapped to run to the primary binding posts, and since an electric current always takes the course of the least resistance, it will circulate by preference through the coil when a resistance greater than that of the coil is placed between the binding posts marked P. But if these binding posts be connected by a short wire offering less resistance than the coil, the current will pass through that route instead of through the coil, and the vibrator will not operate.

The Secondary Current.—The secondary current is derived from another coil of wire wholly unconnected with either the other (primary) coil or the generating cell, but which surrounds the primary coil, whence it receives its inductive influence. This can be more readily appreciated by examining a faradic apparatus of the Dubois-Reymond pattern, where the secondary coil slides over the primary instead of being stationary, as in the cheaper forms of battery. If the battery is started and the secondary coil is completely removed, though having the conducting cords attached, no current will be felt; but move the secondary up to and over the primary and it will be found that a current is induced in the secondary coil, which becomes intensified in proportion the extent to which it is pushed over the primary or exposed to its influence, the current being induced only in that portion of the coil which covers the primary.

Faradic Apparatus.—This brings us to the consideration of special forms of the faradic apparatus, or rather special arrangements of coils. The best form of apparatus, and the one generally used now, particularly for gynæcological work, is that referred to above as the Dubois-Reymond with the secondary coil movable. The best and most useful forms of this pattern have two, and some three or more, secondary coils of different sizes and length of wire.

The faradic apparatus employed by Apostoli (made by Gaiffe, of Paris) is supplied with two secondary coils—one of coarse wire and the other of fine wire. According to de Watteville the construction is as follows, viz.: the inducting coil (primary) is composed of wire 0.7 mm. in diameter, 25 metres long; the secondary coarse wire is 0.7 mm. in diameter, (number 21 of the American gauge) 75 metres long; the secondary fine wire is 0.175 mm. in diameter (No. 33), 450 meters (about 500 yards) long. This is operated by two bisulphate of mercury cells, similar to those used in Gaiffe's pocket battery, with which many are familiar. This makes it serviceable as a portable battery. It has binding posts or slots for attaching it to a stationary battery or cells so that it may be employed for office work, and can be operated by one or more Leclanché cells, if desired. This battery has proved very serviceable for many purposes. It has not, however, been sufficient for all purposes in gynæcological work, and the author was led to suggest some improvements in a paper presented at the recent meeting of the American Electro-therapeutic Association.

The battery introduced by Engleman a few years ago was a decided advance towards the perfection of the faradic apparatus. It is fashioned after one of French origin, described in de Watteville's work, and has three secondary coils. The coarse wire is composed of No. 16 wire* (1.4 mm.) about 75 yards (66 metres) long; the intermediate coil is composed of No. 21 wire (0.7 mm.) about 225 yards (198 metres) long; and the fine wire coil is of No. 31 wire (0.225 mm.) about

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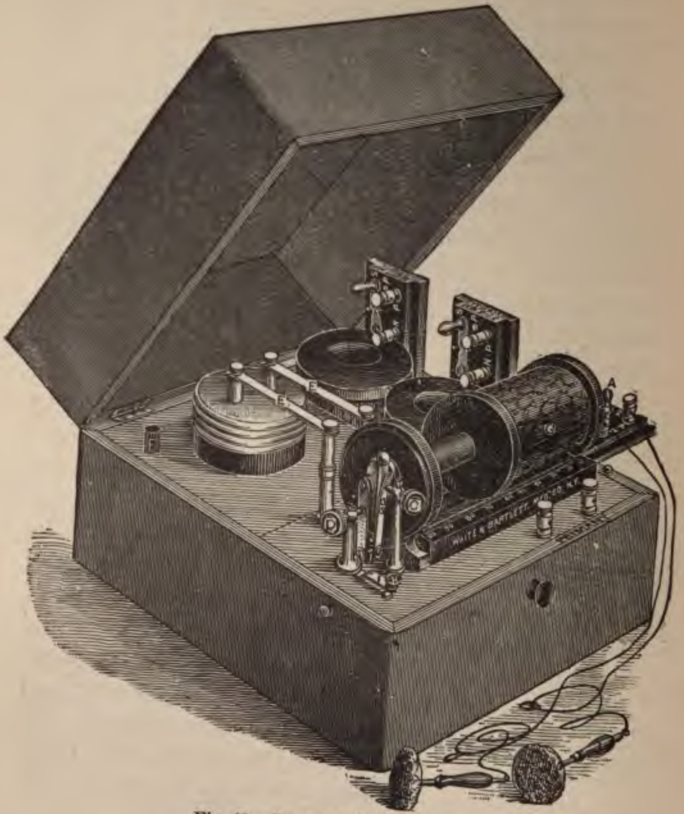
*Brown & Sharpe's American guage.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WAITE & BARTLETT MFG. CO. N.Y.

Fig. 13.—ENGLEMAN'S BATTERY.

660 yards (600 metres) long.* Although to be regarded, as by far, superior to any other apparatus of the kind made in this country, it has proved inadequate for many purposes in gynæcological work, in that the finest coil is not sufficiently sedative for some very sensitive conditions which we meet. The suggested improvement referred to above is as follows, viz.: that the coarse wire coil and intermediate be retained as they now exist, and in place of the finest coil, which is made of No. 32 wire, about 660 yards long, a coil is to be wound with 800 yards of No. 32 or No. 34 wire tapped at 500 yards, making three lengths upon one spool, viz., one of 300 yards, another of 500 yards, and the total length 800 yards. In addition, it was proposed to have another spool or coil upon which is wound 1,500 yards of No. 36 wire, which is tapped at 1,000 yards, thus giving upon the same spool three coils of different lengths of wire—one of 500 yards, another of 1,000 yards, and another of 1,500 yards, the total length. By this arrangement, the most sensitive conditions may be brought under the therapeutic influence of this current, such conditions that would not permit its use from other coils.†

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* The size of the wire according to the American guage are as they are used in the Engleman battery made by the Waite & Bartlett Manufacturing Co., and may not correspond exactly with the measure in millimetres as given.

† This arrangement of coils is under consideration by a

In the author's experience this arrangement has been most satisfactory, it affords a variation in the current which gives it a wide range of usefulness in diseases of the pelvic organs. The longest coil of finest wire gives a current very grateful and soothing to many acutely sensitive and inflamed conditions which could not endure the current from a shorter coil even of the same size wire. After awhile, however, so much improvement is brought about that it will cease to be of benefit and a more stimulating current from a shorter wire will be necessary, and can then be employed with advantage, though previously it would have been irritating. For this reason the long coil has been split up into different lengths, and it will be found to be much more convenient than changing the spool every time it is desired to change the current. Often times after using the extreme length of coil, it will be best to use a shorter length at the same sitting, in order to secure the desired degree of sedation. In other words, the object is to produce complete relaxation and insensitiveness, and commencing, in very sensitive conditions, with the longest length of wire, a shorter length of the same size is used as soon as the parts have become sufficiently accustomed to the current to permit it; and it was to facilitate the application that the differ-

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committee appointed by the American Electro-therapeutic Association, who are to test its merits and report at the next meeting.

ent lengths have been placed upon one spool, and a switch arranged upon the end for making this change easy. It will be necessary to turn the current off completely in making the change, then it can be gradually increased again.*

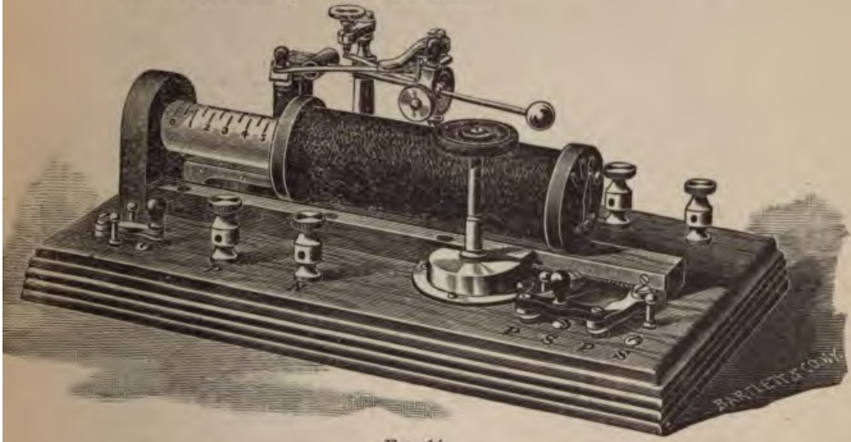

Fig. 14.

Fig. 14 represents a coil of fine wire (No. 36) made by the Law Telephone Co., arranged after the plan suggested by the author, with a switch on the end of the spool for changing the length of the wire. It has been found very satisfactory where fine wire faradization is required, but it has no coarse wire coil. The primary current can be used in place of the coarse wire secondary, though the apparatus could be rendered much more useful by adding a number of secondary coils as suggested on a preceding page. The cells for operating the coil are placed in any convenient location at a distance from it and connected by wires.

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* It may be best to have changeable primary coils adapted to suit the different spools of the secondary. This is offered

In the apparatus of this pattern, the current is increased by sliding the secondary coil over the primary, and is diminished by removing it when the conducting cords are attached to the secondary coil or when using this current. When the primary current is used, it should be moderated by covering it with the secondary coil to start with (the coil being closed by connecting the binding posts of the secondary coil with a loop of wire to complete the circle); and the strength is increased by removing the secondary coil (uncovering the primary).

In very sensitive conditions, instead of increasing (turning on) the secondary current by moving the coil up over the primary, it is best to introduce into the secondary circuit, with the patient, some good controller (like the Massey, used for regulating the galvanic current), move the secondary coil completely over the primary and turn on the current gradually. The very best effect of the secondary current is never obtained until all of that coil is receiving the full inductive influence of the primary, which it does only when the primary is completely covered by it. This fact led to the adaptation of a rheostat or regulator by the author (see fig. 16) to be introduced into the battery circuit (that from the generating

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as a suggestion, and must be decided by the manufacturing electrician. So far it has not been found necessary. It could be readily arranged and a movable primary attached for each separate spool.

cell or cells) to secure the same end and proportion the current to the coil employed. A rheostat of this kind is necessary in manipulating the coils described above which are operated by four, six, or eight Leclanché cells arranged in series. Switches for utilizing one or more cells successively will be an additional advantage, but cannot take the place of the rheostat for the reason that it will be necessary to remove the secondary coil every time it is desired to increase the battery current by adding another cell, and the increase is not so gradual, as with the rheostat.

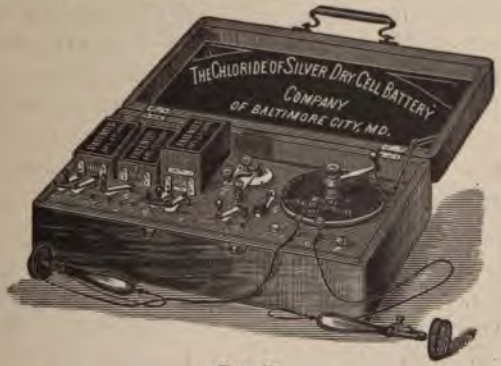
THE CHLORIDE OF SILVER DRY CELL BATTERY
COMPANY
OF BALTIMORE CITY, MD.

FIG. 15.

The cut Fig. 15 represents a battery constructed after the plan suggested in a paper read before the American Electro-therapeutic Association. The coils are under the key-board out of the way, and are made stationary over the primary, a rheostat in the secondary circuit regulating the current. By means of a switch the different coils are thrown into the circuit. It is arranged for being operated by twelve chloride of silver cells which can be thrown into use separately or together. It can be used as a portable or stationary battery, and is in every way satisfactory for obtaining the effects of the different coils.

German Silver Wire Rheostat for Regulating the Current of the Battery Circuit of the Faradic Apparatus.—As has been mentioned above, the sedative quality of the secondary current is more pronounced when the secondary coil completely covers the primary; that is, when the secondary coil is receiving the full inductive influence of the primary. It has been observed that when the secondary is only one half or two thirds over the primary coil, the current becomes unbearable, but when it is moved all the way over the current becomes immediately soothing. This fact has been repeatedly demonstrated by rapidly pushing the secondary coil all the way up when the painful point was reached. The discovery of this fact led the author to suggest the use of a rheostat constructed of very fine German silver wire to be introduced in the battery circuit for controlling the current from the generating cell or cells, so that the application could be made from the start with the secondary coil receiving the full induction of the primary. In commencing the application, the secondary coil is removed and the battery started by turning on the least strength of the current that will cause the vibrator to move smoothly, then the secondary coil is slowly moved up to its full length. Afterwards, the strength of the current is gradually increased to the point desired, by means of the rheostat which affords perfect control of the current. The strength of the current is decreased by reversing the manœuvre.

The many advantages of this arrangement will be appreciated by those who have been in the habit of using the current after the other plan, increasing the strength by moving the secondary coil up over the primary, and being obliged to stop before more than half the wire of the coil has been made use of.

One form of this rheostat, shown in figure 16, consists of a circular disc of hard rubber four inches in diameter with the German silver wire arranged in a loop fitted in two grooves around the circumference, giving a resistance of ten ohms, sufficient to operate six or eight Leclanché cells. A thumb wheel is attached to the centre of the disc for revolving it. Two arms moving in the grooves complete the circuit through the loop of wire, which is made shorter, and consequently the resistance becomes less, as they are advanced by turning the disc.

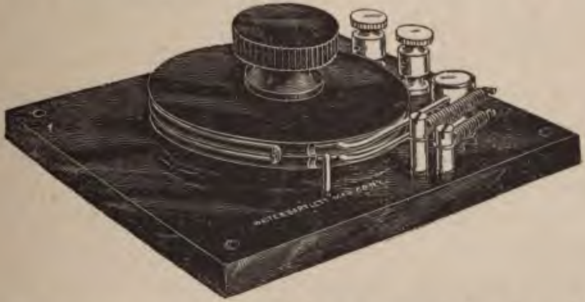

Fig. 16.—Author's German Silver Wire Rheostat for Battery Circuit of Faradic Apparatus.

Another form of this rheostat is made by coiling the German silver wire around a hard rubber cylinder a little larger than a lead pencil, the turns being separated sufficiently for insulation. The circuit is broken by having one end of the wire leading from one pole of the generating cell attached to one extremity of this German silver wire coil, the other end being connected with a slide that moves over the surface of the cylinder and coil. As this slide is advanced along the cylinder, the length of the silver wire coil is diminished and with it the resistance. This is probably the more convenient of the two forms of this rheostat, because it takes up less space, but the current can be increased more gradually with the one first described.

Greater convenience in manipulating the current can be secured by having a switch arranged for turning on either one, two, three or more cells at a time through this rheostat.

Some forms of faradic apparatus have the secondary coil permanently fixed over the primary, and the current is moderated by interposing between the primary and secondary coils, or between the primary coil and bundle of iron rods, a metallic tube. This does not shut off the secondary current completely, and it is always perceptible at the start in this form of apparatus, which is a serious objection. To increase the current this tube is withdrawn, and it is pushed back to decrease it. Should there be a longitudinal slit or fissure throughout the extent of this tube it would not exert a modifying effect as it does when it is perfect.

A most convenient and useful form of apparatus is one which is arranged with portable cells, and allows its attachment to stationary cells for office work, the portable cells being then disconnected. The best form of cell for operating the faradic apparatus is undoubtedly the Leclanché, which is decidedly preferable to the red acid cell and not much more bulky. They should be kept in good order, with clean zincs, so they will be uniform and regular in their action. The form of battery described above, arranged with a bisulphate of mercury cell for use as a portable battery, with an attachment for permanent cells for office use, is for obvious reasons a most useful form of battery. There is no fluid to be spilled during transportation, and the bisulphate of mercury solution can be made ready for use in a few moments.

The chloride of silver cell has been employed for operating the faradic battery, and when the coils are properly portioned, it will last about one hundred hours. (See fig. 17.) A very convenient cell for this purpose, also is the so-called dry Leclanché, described in connection with the galvanic current.

One form of apparatus which is very little understood, and which differs in many respects from the others, is the Kidder coil, made by the Kidder Manufacturing Co., of this city, the virtue of which is extolled by Rockwell. It is the experience of the author, however, that this coil furnishes a current

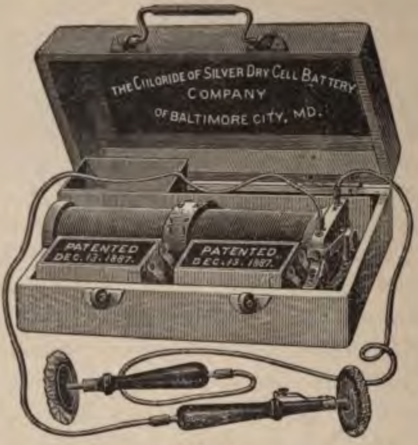
THE CHLORIDE OF SILVER DRY CELL BATTERY
COMPANY
OF BALTIMORE CITY, MD.
PATENTED DEC. 13. 1887.
PATENTED DEC. 13. 1887.

Fig. 17.

Fig. 17 represents a very convenient portable faradic battery, which resembles in design one made by Gaiffe, of Paris, and used by Apostoli. Some alterations are necessary, however, to make it furnish a suitable current for gynæcological work. The core and the wire of the primary coil are too small, and two more cells should be added; and the secondary coils are not quite sufficient. The makers have assured me that they will adopt the following suggestions, which will make it a very satisfactory portable battery, viz.: the primary coil should be wound with No. 21 wire; the coarse wire secondary coil should be wound with No. 20 wire, seventy-five yards long; and the fine wire secondary should be wound with No. 36 wire, 700 yards long, tapped at 500 yards, which will give three variations of the fine wire secondary current.

inadequate, in many respects, for gynæcological purposes. It does not give a sufficiently intense current, even from the longest and finest of its coils, for a pronounced and prolonged sedative effect; and the vibrations are harsh, the rapidity of the interruptions being insufficient. The arrangement of the coil is peculiar. The primary is blended with a portion of the secondary, an arrangement of switch or binding post allowing the use of this combination when desired. The secondary coil is made up of different sizes of wire joined together, forming one complete coil, but tapped at intervals so as to obtain the different varieties of current, with their different effects, from the different coils of wire.

To make this better understood, imagine a wire of considerable length, say 200 yards, composed of four different sizes of wire—Nos. 18, 22, 26 and 30—joined together in one continuous strand, and the whole wound upon one spool. At the point where the No. 18 terminates or joins the No. 22, a wire is connected which leads to a binding post or a button of the switch. Likewise where the No. 22 wire joins the No. 26, a wire is connected leading to another binding post or button of the switch, and so on for the other numbers. On some of the batteries the selector for these currents from the different size wires is in the form of a switch, with from four to five buttons lettered from A to D or E; in others there are the same number of binding posts, lettered in the same manner. It will be seen that this arrangement allows the use of the current from the coil of No. 18 wire, or any other size wire in the series, alone, or any of them or all of them may be combined.

The advantage of this arrangement can only be appreciated by clinical experience with it. Though not suitable for gynæcological work, it has been found very useful for applications to the external surface of the body in neuralgic conditions of certain superficial nerves.

Though the difference of the effect of the current from coils of different size and length of wire may be denied by some, it is a fact easily demonstrated clinically. It is true that the difference is not so perceptible when applied to the skin with its high resistance as when both poles are applied to a mucous surface like the vagina where the resistance is low. It is granted then, that this difference depends, to a certain extent, upon the different conditions of resistance under which this current is used. Unquestionably the current from the long fine wire is a more intense current with a greater electro-motive force capable of overcoming resistance much more readily than the current from the short coarse wire which has more volume.*

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* Argument in support of this point will be seen further on.

The author has taken great pains to test the different forms of faradic apparatus for their effect in gynæcological work, and to ascertain from the different manufacturers the size and length of the wire of which their secondary coils are constructed. It has been ascertained that heretofore the different manufacturers have constructed their coils upon an entirely independent basis. As there has been no standard, their construction has been more a matter of convenience than consideration for any physiological effect of the current to be derived therefrom. This is to be deplored since there can be no uniformity of action with such variety in apparatus, and explains why some investigators have failed to get the highly satisfactory results claimed by others for this current. The makers are not entirely to blame for this, since the physicians who have used their batteries have looked upon such points as a matter of indifference, and have not insisted upon the necessity of their improvement. The truth is that electricity has been so little understood by the profession, that they have depended upon the manufacturers of electrical instruments to tell them what they want. The time has come when the physician who attempts to use this agent should thoroughly understand it beforehand, and should know just what kind of an apparatus he needs, and how it is to be used. But little progress can be made in this direction until the subject is given more attention by our colleges and post-graduate schools. It is to be hoped that they will soon see the necessity of teaching this branch of therapeutics.

As a consequence of this indifference to the necessity of some uniformity in faradic apparatus, the secondary coils found upon batteries in the market to-day, vary from No. 15 to 30 wire and from 60 feet to 200 yards in length. It is unusual to find a secondary coil composed of wire smaller than No. 26 or 30 and longer than 100 to 200 yards, and the majority are made of No. 22 or No. 26 wire about 200 feet long. With such a variation in apparatus, it is not surprising that uniform results have not been obtained with this current. The ordinary faradic batteries are not suited for gynæcological work, and satisfactory results must not be expected from their use. A special form comprising properly proportioned coarse and fine wire secondary coils, are essential, and is only to be found in some one of the modifications of the apparatus employed by Apostoli, such as those recommended in the preceding pages.* The author has endeavored to overcome this difficulty and hopes that by the time this work is offered to the profession, suitable standard batteries can be obtained from any first-class maker.

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* Tripier developed the value of the current of quantity; Apostoli that of tension.

It is probable that imperfectly constructed electrodes have, in a measure, been accountable for some failures with the bipolar method. One purchased by the author from a prominent and reliable maker had but one connection on the bipolar vaginal electrode, the other being imperfect at one of the metallic surfaces. Therefore every electrode should be tested upon the hand before it is used for the first time, and subsequently if there is any reason to believe that the connections have been impaired.

It is not advisable nor is it necessary to depend upon the statement of makers as to the length of the wire constituting their coils. Knowing the size of the wire, or ascertaining it if it is not known positively, its length can be determined by measuring its resistance by means of a reliable apparatus. This may be done by means of a direct reading ohm-meter, by placing it with the coil in the circuit and reading from the instrument the resistance in the circuit. The Wheatstone bridge can also be used for this purpose. Neither of these instruments are readily accessible, however, unless one is near one of the great medical centers where scientific instruments are manufactured, or near some scientific institution. The most practical method of arriving at the resistance of a given coil is by means of the resistance coils furnished with the best forms of cabinet apparatus; comparing the unknown with the known resistance. This is done by withdrawing from the circuit the unknown resistance and substituting the known resistance, as furnished by different coils of German-silver wire. These coils are arranged in series from 5 to 5,000 ohms, so as to allow any number of ohms of resistance to be thrown into the circuit by means of switches connected with the separate coils.

To measure the resistance of a coil by means of these resistance coils, called the rheostat, connect the terminals or binding posts of the coil to be tested with the binding posts of the galvanic battery, and turn on a sufficient number of cells to cause the milliampere meter to register either five or ten milliamperes, then throw the switch on the button marked "*milliampere meter and rheostat*," which throws the coil out of the circuit and substitutes the rheostat of German silver wire resistance coils. By means of the switches connected with these coils, throw as many into the circuit as will bring the needle of the meter back to the point it marked before. The total resistance, as denoted by the figures upon the switches used, will give the resistance in the coil under test.

In the following table the column of figures on the right gives the number of feet to every ohm of resistance in the size wire opposite to it in the column on the left, marked Gauge No. at the head.

Table of Resistance of Different Sizes of Copper Wire, according to Brown & Sharp's American Gauge.

Gauge No.	Weight. Feet per Pound. (Silk covered.)	Ohms of Resistance per 1,000 Feet.	Feet per Ohm.
14	75	2.504	400.
15	95	3.172	316.
16	120	4.001	230.
17	150	5.04	198.
18	190	6.36	157.
19	240	8.25	121.
20	305	10.12	99.
21	390	12.76	76.5
22	490	16.25	61.8
23	615	20.30	48.9
24	775	25.60	39.0
25	990	32.2	31.0
26	1,265	40.7	24.6
27	1,570	51.3	19.5
28	1,970	64.8	15.4
29	2,480	81.6	12.2
30	3,050	103.0	9.8
31	3,920	130.	7.7
32	4,930	164.	6.1
33	6,200	206.	4.9
34	7,830	260.	3.8
35	9,830	328.	2.9
36	12,420	414.	2.4

It will be seen from the above table that, knowing the size of the wire composing a coil, its length may be estimated approximately, either by weighing and deducting the weight of the spool and attachments, or by measuring the resistance of the coil. To compute its length by weight, after deducting the weight of the spool and attachments of the coil proper as detached from the battery, compare it with the second column of the table opposite its number. For instance, if a coil is composed of No. 32 wire and is found to weigh one pound, it will measure 4,930 feet, or 1,643 yards. This is not a very convenient or satisfactory method, unless an empty spool and attachments are accessible for weighing or the weight is known.

To compute the length of the coil by measuring the resistance, after ascertaining the total resistance of the coil in ohms, multiply by the number of feet per ohm, as shown in the table opposite the number of wire, and the result, after marking off the decimal point to the right, will give the length in feet. Divide this by three and you have the length in yards. For instance, if a certain coil shows a resistance of say 200 ohms, and it is composed of No. 36 wire, its length will be 200 multiplied by 2.4 feet (the number of feet in every ohm of this size wire), which will be 480 feet. This divided by three, gives the number of yards—160.

The Vibrator or Current Breaker.—Every apparatus, for effective work, should be capable of furnishing three kinds of interruptions, fine, coarse and slow, which may readily be accomplished by arranging the different vibrators around the head of the core. The fine vibrations should reach the maximum attainable, at least 200 per second. The coarse vibrations should number from 40 to 60 per second, which corresponds with what is furnished by the best of the ordinary forms of the faradic apparatus to be found in the market. The slow vibrator should allow a variation of from 2 to 5 per second. It will be understood that it will be impossible to obtain this degree of perfection in a cheap instrument. By a switch arrangement, these can be thrown separately and independently into the circuit, which will be found very convenient, as much time can be saved by leaving the adjustment unaltered and changing the character of the vibrations by a turn of the switch. It is necessary that the vibrator should run perfectly smooth, without jerk or skip, to secure which it must be carefully adjusted, and the generating cells and connections must be kept in good condition. The cells must be renewed often if they are used much, as they deteriorate rapidly when used for operating the faradic coil. The resistance is so little that it must not be expected that they will last as long as cells used for galvanic work. For obvious reasons, cells employed for galvanic work should not be used for operating the induction coil. The importance of varying the rapidity of the interruptions to meet different requirements will be shown further on.

THE ACTION OF THE SECONDARY FARADIC CURRENT.

There has been much controversy over the action and different effects obtainable from the current as derived from the coarse and fine wire secondary coils of the faradic apparatus, and instead of throwing any light upon the question it has been made more obscure. Unfortunately, the literature of the subject is in such a chaotic state upon this point that a study of it is more apt to bring confusion than enlightenment. One writer will declare that there is a marked difference between the action and the effect of the primary and secondary currents, and also in the current as derived from differently constructed secondary coils, while another will deny this distinction and declare in favor of one secondary coil for all purposes. To any one who has had practical clinical experience with properly constructed apparatus this appears unwarranted, and it is unfortunate, because the faradic current is a therapeutic agent of too much value to be discarded or ignored, as it has been on account of this confusion.

Those who have disputed the diversity of effect to be obtained from secondary coils of different sizes and lengths of wire have evidently had no experience in the matter, or else they have been working with imperfect apparatus, disregarding the fact that this is the most prolific source of uncertainty and failure. One writer declares that the length and size of the wire is a matter of indifference, and separate coils of coarse and fine wire are unimportant, since all depends upon the number of convolutions of the wire in the coil and the different resistances encountered in using the current, and claims that one coil is sufficient for all purposes. The fact that the finer the wire, and the greater its length, the greater the number of convolutions possible in a given coil is ignored, as well as the fact that the short, coarse wire, offering less resistance, allows a current of more volume (amperage) to flow through it, and the increased resistance in the long, fine wire cuts down the volume,* while the electromotive force is increased by multiplying the number of convolutions. He admits, however, that there is an advantage in a number of coils of different length and size of wire, in that it increases the range of the battery and its available electro-motive force. He admits, also, that the less the resistance in the coil the greater the volume of the current flow, and *vice versa*; that the greater the volume of a current flowing through a muscle the more violent the contraction; that the current from the long, fine wire, having a small volume and high electro-motive force, would be more serviceable for the relief of pain. Therefore, after taking much pains to upset the claim, of the difference of the current as derived from coils of different sizes and lengths of wire, he eventually admits the truth and has added nothing to the subject, but has, instead, rendered it more obscure to those of his readers who have not a clear understanding of the laws of force and resistance as applied to this agent. In an effort to defend his assertion that one secondary coil is sufficient for all medical purposes, he suggests the use of a rheostat for interposing an artificial resistance in the secondary circuit, which he thinks should modify the action to suit the different requirements. In support of this idea, he says that the current from the coarse wire coil is not necessarily always one of great volume, since much depends upon the resistance it encounters in penetrating the skin, and that in order to insure the necessary volume the electrodes must be large and well moistened; that it is purely a question of relationship of resistance and electro-motive force, which is all very true and an admission of the very claim that he started out to prove incorrect. The theory of the rheostat in the secondary circuit interposing a resistance that will alter the volume or electro-motive force so as to vary the effect, cannot be demonstrated. The rheostat used in the secondary circuit will be serviceable for graduating the current to a nicety in applying it, and has often been used by the author and others for this purpose; but it in no way alters the effect of the current in producing muscle contraction or nerve sedation, as he has suggested.

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*The term volume is synonymous with amperage or current strength.

The fact is, that for producing muscle contraction a current of volume is necessary, and for sedation a current of high tension or electro-motive force is required. But in addition to this, some attention must be paid to the external resistances encountered; for instance, the skin must be well moistened and the electrodes should be of liberal size to secure the best effect upon the muscles, since the current used for this purpose (that from the coarse wire) has a low electro-motive force. In other words, in using the current of volume, with low electro-motive force, the resistance must be diminished as much as possible to allow its penetration. For sedation, however, the electrodes, especially that for the active pole, may be small.

Some authors have evaded this question, while others have simply made assertions without sufficient evidence to support them. De Watteville says: "Though thick and thin wire coils do not differ in their fundamental physiological properties, yet their respective physical constitution endows them with very different effects."

In gynæcological work, where now the bipolar method of Apostoli is the one most universally employed, the conditions are so entirely different from those encountered in the application of the current to the external or skin surface of the body, that its possibilities can hardly be appreciated by one whose experience is limited to the older method. It must be understood, that in the bipolar method both poles are applied to a moist, mucous surface (the vagina or uterine cavity) where there is very little resistance to the penetration of the current, that they are separated only an inch or an inch and a half, and both the electrodes are bare metal surfaces, all of which operates to diminish the resistance encountered by the current. Hence the current of volume and low electro-motive force (from the coarse wire) is afforded a more favorable opportunity for penetrating to the muscular structures beneath the surface and its effect is more appreciable, while the other current (from the fine wire), with high electro-motive force, produces less pain in penetrating the mucous surface, and reaches more readily the deeper structures, than when applied to the external surface of the body where the resistance of the skin is enormous. The confusion and diversity of statements upon this point have resulted from a disregard of these different conditions of resistance under which the current is employed in the two methods. I will admit that under adverse circumstances, as where high resistance is encountered in its administration, this dissimilarity of effect of fine and coarse wire faradization is not so pronounced; also, that the current from the fine wire coil may appear to have more muscle-contracting power; but it does not alter the fact that the current from the long fine wire coil is a current of high tension or increased voltage, while that from the short, coarse wire is a current of greater amperage and diminished voltage; and it is this difference of quality which allows the manifest difference in their physiological effect, when the relationship of external resistance is appropriate. When the resistance is high, of course the current with a greater electro-motive force is more active, because it has more power to penetrate the resistance; but reduce this resistance and the current of volume will demonstrate its muscle-contracting power.*

A practical demonstration of this point is afforded by placing the bipolar electrode in the vagina of a subject with healthy pelvic organs, and using first the current from the fine wire coil, then that from the coarse wire coil. The former will not only be bearable, but is rapidly sedative, and not at all painful, while the latter will be painful and unbearable applied in the same manner, which shows that the one is a sedative current and the other is painful, because it induces sharp muscular contraction. As a further demonstration, grasp the bipolar electrode in one hand, which has been well moistened, so both metallic surfaces are included, and try the effect of the two currents carried to the point of greatest tolerance: that from the fine wire will be intense, but bearable, and after a few moments it feels softer and less perceptible—soothing; while the other will produce very painful contraction and is quite unendurable even for a short time. The different effect of the current from coils of different sizes and lengths of wire may be similarly demonstrated.*

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* To demonstrate the difference of volume or amperage of these two currents under the same condition of low external resistance, place a milliampere meter in the circuit of each separately, with no other resistance, and make and break the current of the battery circuit slowly by means of the single contact key, or by moving the vibrator with the finger. The deflection of the needle produced by the current from the coarse wire coil will be very noticeable, while with the current from the fine wire coil it will be perceptibly less.

Not only is there a great difference in the faradic current as derived from secondary coils of long, fine wire and short, coarse wire, by reason of the difference in their volume and electro-motive force, but there is a notable difference in the current from different lengths of the same size wire, and for the same reason. The current from the long, fine wire coil has an increased electro-motive force, because the increased length allows more convolutions to be exposed to the inductive influence of the primary, while its volume is cut down because of the resistance offered by the great length of fine wire. It stands to reason, therefore, that the electro-motive force is diminished if the length of the same wire is lessened, and the volume of this current is increased, because the resistance is lessened by shortening the wire. This ought to be clear to any one, and if so, the difference of result must be appreciated and admitted.

The result cannot possibly be the same if one coil of long wire is used and the attempt is made to vary the qualities of the current by varying the extent to which it is exposed to the influence of the primary, as has been claimed by one writer upon this subject, since the current must always traverse the whole length of the long wire with its resistance interposed, while only the inductive influence of the primary is varied. The force of the current is certainly modified, but its volume cannot be increased since the internal resistance of the coil is always the same. The introduction of a variable external resistance like a rheostat or controller in the secondary circuit in like manner alters the force of the current, but it in no way changes the volume, if only one coil is employed, except by reducing it still further.

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* The cells for operating the battery must be arranged in series, and not in parallel.

Poles of the Induced Current.—It has been erroneously supposed that there is no difference in the poles of the secondary faradic current, because it is regarded as a to and fro current, the poles being constantly reversed with every make and break of the battery or primary circuit, and consequently their position is therapeutically unimportant. It is true that there is a constant change of polarity which may be demonstrated by placing a delicately adjusted milliampere meter in the secondary circuit alone, and interrupting the current slowly by means of the single contact key, or by moving the vibrator with the finger. With each make and break it will be observed that the needle will deflect in an opposite direction to about the same degree.* Two currents are established, one with the make and the other with the break of the battery or primary circuit which flow in opposite directions, as shown by this experiment, but it has been estimated by careful measurement (Dr. Gordon) that the secondary break current is thirteen times stronger than the make current, hence, though both may be appreciable through the low resistance of the meter, the feebler (make) current has not sufficient electro-motive force to penetrate the resistance of the human structures, and only the stronger (break) current is perceptible. Since that always flows in one direction it is endowed with polarity, which can be demonstrated by experiment.

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*This can be more readily shown with the coarse wire coil because this current has more volume. If the vibrator is al-

To comprehend the reason for this difference in strength of the make and break currents, we must consider the fact that the force of the make current of the primary is expended upon the core, and its entire inductive influence is exerted in charging the secondary coil. It has been shown that the primary current is only perceptible when contact is broken at the vibrator, no effect being noticed when contact is made. The fact can be demonstrated by taking an electrode in each hand and interrupting the current slowly at the vibrator. It will be observed also, by

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lowed to run, interrupting the current rapidly, the needle will, of course, remain stationary, because it is incapable of responding to every interruption.

increasing the strength of the current to a point where decided muscular contraction is produced, that the contractions are stronger, and the painful sensation greater, at the electrode connected with the negative pole. The same is true of the secondary current, its action being appreciable only with every break of the primary circuit, and the pole marked negative is noticeably more irritating. It is to be expected then, that if the break is thirteen times stronger than the make current its impulse is more perceptible through high resistances, and its polarity will be manifested; a distinct polarity must, therefore, be recognized.

To demonstrate the polarity of this current, attach two conducting cords with electrodes to the binding posts for the secondary current, placing the electrode connected with the terminal marked negative, over the motor point of some muscle and the other electrode on some indifferent part of the body. Turn on the current, using the slow vibrator, and increase the strength by moving the secondary coil up over the primary until a point is reached when a contraction is produced in the muscle at every interruption. Now reverse the poles by means of the pole changer for this current without disturbing the position of the electrodes, thus making that over the motor point positive instead of negative, and the contraction in the muscle will cease, showing that there is a marked difference in the physiological properties of the poles.

The difference of the effect of the two poles upon the sensory nerves can be as readily demonstrated. Place an electrode connected with first the negative, then the positive pole upon an abraded surface and use the fine vibrator. When the negative pole is in contact with the abraded surface an irritation is produced, but when the positive pole is in contact with the same surface a soothing effect will be noticed.

The distinctive features of the poles of the faradic current are purely of a mechanical nature, though at the same time physiological, since the current exerts no chemical action. But it is possible, that by causing it to have sufficient volume, it will be endowed with the same chemical capabilities as a galvanic current. As ordinarily employed in medicine, however, the action is merely mechanical; and it is not an alternating but an interrupted induced current. Enough has been said to show that this current is possessed of distinct polarity, and in utilizing it for medical purposes the location of the poles must be regarded as of equal importance as in the application of the galvanic current.

PHYSIOLOGICAL EFFECT OF THE INDUCED CURRENT AND METHOD OF APPLICATION.

From what has been said, the main features of the faradic current are now fairly understood, and it will only be necessary here to repeat, that the current from the short, coarse wire coil is a current of volume, and that from the long, fine wire is a current of high tension of electro-motive force; that the one is more appropriate for inducing muscular stimulation and contraction, the other being utilized for effecting nerve sedation and circulatory tranquilization; but the conditions of external resistance must be appropriate for the physical qualities of the current employed, in order to obtain the result desired. When the current of volume is used, the resistance in the external circuit must be lessened, as much as possible, in order to favor its penetration, because it has a very low electro-motive force ; otherwise its action will be feeble, and the result will be unsatisfactory. This current from the short, coarse wire secondary coil, if applied in a suitable manner with proper electrodes, which reduce the resistance, should be best for promoting muscular tone; and, though the current from the long, fine wire secondary coil may be utilized for promoting muscular stimulation, its most pronounced effect will be in the direction of allaying pain and establishing local anæsthesia.

The rapidity of the interruptions has an important bearing upon the effect produced by this current. With coarse interruptions it is more stimulating or irritating ; with rapid interruptions it is more soothing and sedative. Hence, in using the current of volume for muscle stimulation, the interruptions should be coarse, and with the current of tension for producing sedation they should be rapid. For muscle stimulation it is desired to produce an alternate contraction and relaxation of the muscular fibrès which will resemble the normal physiological action, and the interruptions must be slow, so as to allow them time to recover and again respond in a normal manner. In other words, a sufficient time must be allowed between the interruptions to permit the molecular changes to take place. When the interruptions are coarse, though the muscle as a whole may appear to be in a constant state of contraction, its fibres undergo an alternate contraction and relaxation. If the excitation of a motor nerve is rapid, tetanic contraction is produced, during which relaxation does not occur. When distinct contraction and relaxation take place the normal physiological action is closely imitated.

For the very best sedative effect the vibrations should reach the maximum of rapidity attainable, and should be perfectly smooth and regular, with no possible chance for jerks or shocks. Much, therefore, depends upon the method of applying the current, for the so-called sedative current can be made to stimulate by rendering the vibrations coarse. It can, likewise, be made stimulating by increasing the strength of the current too rapidly, and maintaining it throughout the entire seance at a point where it is constantly and forcibly appreciated.

Sedation is established by effecting a temporary paralysis of the sensory and motor nerves: their sensibility is obtuned and the painful contraction of the muscles is overcome. When the interruptions are rapid, the muscles are unable to respond to every impulse, and a tetanoid condition is produced which shortly results in complete relaxation. Apostoli believes that faradization relieves by setting up vibrations in the nerves, traveling in opposite direction to the ordinary or painful impulses. Morton believes the effect is obtained by simple agitation of the mass of the constituent elements of the nerve fibre, and thus an annulment of its capacity to conduct pain impulses is brought about, just as concussion or anæsthesia of brain tissue may be said to annul its capacity to respond to sensory impulses.

Two effects are obtainable then from this fine wire current, depending upon the method of application. (1) *Stimulation*, when the intensity of the current is maintained throughout the entire seance at a point where it is constantly and forcibly appreciated by the patient. (2) *Sedation*, when the increase is so gradual as to make the action barely perceptible, and the application is continued for a time without being perceived. The reason for this distinction is found in the fact, that so long as the interruptions are felt the sensory and motor nerves continue to respond, and have not lost consciousness. It is certain that there must be a response involving contraction and relaxation, even where a tetanoid condition is observed, as long as the impulse is appreciable, and the effect must be regarded as stimulating just as long as this condition continues, and sedation is not reached until relaxation and local loss of consciousness occurs. This, then, is the point that must be reached and maintained for a time, in all applications having for their object sedation, before the seance is brought to a close; since to stop short of it only produces an intense stimulation, beneficial for many conditions, but absolutely unsuitable and unsatisfactory where perfect sedation is required. In other words a local loss of consciousness must be established before it can be considered that the desired effect has been produced.

In the presence of pain or an inflammatory process, where careful sedation is urgently demanded, much care is necessary to avoid increasing the strength of the current to a pitch that over-stimulates—irritates—and prevents the accomplishment of the end anticipated. If, therefore, during an application, when the highest intensity of the current is reached, there is no evidence of declining sensibility after a few moments' continuance, it is advisable to reduce the strength to a proper limit. When a stimulating effect is desired, where pain is an insignificant symptom, and when no inflammatory process is present, but where stimulation with the current from a coarser or shorter wire would not be endured without discomfort, the current from the fine wire may be used to produce this effect by maintaining the intensity of the current at a point where it will be constantly felt during the entire application. A disregard for these details may explain some of the failures experienced with this current.

As pointed out by Engleman, the pain of a cellulitis, or other pelvic inflammation, will be relieved by the current from the long, fine wire coil, while it will be aggravated by the current from the short, coarse wire coil; and the pain, swelling and venous distension of a contusion will be relieved by the current from the short, coarse wire coil, while it would be aggravated by the other current. The current from the fine wire coil is to be used mainly for nerve effect and in inflammatory conditions, and the other for muscular effect and for recent injuries associated with venous distension due to traumatism. Painful conditions of the pelvis, due to inflammatory action and their results, and capillary engorgement are to be treated by fine wire faradization. Venous engorgement, as hyperplasia, subinvolution, and recent contusions, unassociated with inflammatory action, are to be treated by coarse wire faradization. Non-development of muscular structure, as of the uterus, will likewise demand the latter form of application. *It will be appreciated then, that a thorough understanding of the subject and a recognition of the different qualities and effects of the current from different coils is necessary for the accomplishment of anything like satisfactory results, and unless these points* *are recognized and the current properly applied success must not be expected, and when obtained, must be looked upon as purely accidental, so far as the intention of the operator is concerned.* Bear in mind the salient features of the effect of the two coils, viz., that the fine wire coil is for producing sedation and the other for stimulation, and, if a correct diagnosis has been made, certainty of success will be assured.

The effect of this current upon the vaso-motor nerves and the capillary circulation, is worthy of special consideration. In a general way, it may be said to produce contraction of the vessels and an increase of the vermicular movements, which quickens the circulation, combats blood stasis, thereby relieving congestion, and hastens the absorption of effete products. To comprehend this effect, the action of voluntary and involuntary muscles must be understood. In a voluntary muscle the contraction takes place as a whole and by one effort. In the involuntary muscles the contraction is composed of two acts —a distinct contraction and a vermicular motion. The action is not spasmodic in the whole muscle at once, but in each fibre in succession, producing the vermicular movement. The spasmodic contraction in the vessels cuts off the blood supply, and the vermicular contractions produce the normal movement of the vessel walls, increasing the amount of blood passing in a given time; or, in other words, hastens the circulation and produces rapid emptying of the vessels.

Experiments in this direction tend to show that a descending current (positive above and negative below in the direction of the arterial blood flow) increases the vermicular movement of the blood vessels and augments the blood supply to a part, and that an ascending current lessens the blood supply by diminishing the vermicular movements, which is additional evidence of the distinct polarity of this current and direction of the current flow. Bearing this in mind, it can be applied to increase or lessen the blood supply to different parts of the body if the unipolar method is employed.

In this connection, it is well to emphasize the necessity of accuracy in diagnosis, as well as the importance of selection of the proper current to suit the condition under consideration. The special indications will, however, be dwelt upon under the the general head of Electro-therapeutics in connection with the treatment of the individual conditions necessitating its employment, where the method of application will be given more in detail. It will only be necessary to state here that for sedation the application should be continued from 15 to 30 minutes, and that the permanent benefit depends upon this, as it does also upon the frequency of the seances. Stimulating applications, on the other hand, should not be repeated oftener than every second or third day, and their duration need not exceed five minutes.

There are two methods of application in vogue in gynæcological work, viz.: (1) the *unipolar* (the old method), where one pole is applied to the external surface of the body as an inactive pole, and the other in the vagina or uterus as the active pole ; (2) the bipolar (Apostoli's method), where both poles are applied in the vagina or uterus upon one handle or electrode, the poles terminating in a metallic surface encircling the shaft of the instrument, and separated not more than an inch on the uterine electrode, and not more than an inch and a half on the vaginal electrode.

The older method is so generally understood that it is not necessary to devote much space to its consideration. It is still preferred by some electricians, because they believe the current is better diffused, and includes a greater area within its interpolar sphere. The great objection to it has been the impossibility of employing the current in anything like sufficient intensity to make it effective for sedation, on account of the sensitiveness of the skin. This can, in a measure, be overcome by employing a large external electrode, such as the clay pad used with the galvanic current, so as to diffuse it over a greater surface, when almost as intense a current can be made use of as by the bipolar method. This method possesses an advantage over the bipolar in that the employment of an ascending or descending current is allowed, in those conditions where it is desirable to influence the circulation in one or the other direction, which is accomplished only to a limited extent by the bipolar method.

The advantages claimed for the bipolar method are, viz.:

1. The concentration of the entire force of the current upon the organs demanding treatment, and their immediate vicinity.

2. Dispensing with the cutaneous electrode renders the operation less painful.

3. The application of both poles to a moist insensitive surface, which offers very little resistance, permits the different qualities of the current to be better manifested.

4. The contact of bare metallic surfaces, which are necessarily near each other, still further diminishes the resistance.

5. The comparative insensitiveness of the surfaces (vagina or uterine cavity), with which the electrodes come in contact, allows the use of a stronger and, consequently, more effective current with less discomfort to the patient.

Neither method can entirely supersede the other, since both have their separate indications, but of the two, the bipolar will be found to be more generally applicable and useful.

In utilizing the bipolar method some precautions are necessary, viz.: (1.) The electrode should be introduced before the current is turned on, and must not be removed until it is turned off. (2.) It should be supported during the entire seance to prevent its slipping out of position. (3.) Care must be taken during the application to prevent contact of the most external metallic surface on the shaft of the electrode with the sensitive tissues at or near the vulva, and, at the same time, deep pressure should be avoided. (4.) In the intra-uterine application both metallic surfaces must be within the cavity, and contact with any portion of the cervical canal, and especially the internal os, must be avoided.

The internal os is particularly sensitive to this current, and the patient cannot endure it unless the electrode is inserted to the fundus, and is retained in that position throughout the seance. A knowledge of this fact has led the author to condemn the double electrode intended for this purpose, where one metallic surface slides over the other so as to increase or diminish the distance between the poles. The outer metallic surface is necessarily so large (the diameter being increased so as to allow it to slide over the shaft to which the other is attached) that it is impossible to pass the internal os with it, without previous dilatation, unless the canal is unusually patulous. The utility of dilatation to accommodate the introduction of this electrode is questionable, to say the least, and, in the opinion of the author, would counterbalance any good to be derived from the application of the faradic current, unless the dilatation is demanded for other reasons.

The precise measurement of the faradic current for therapeutic purposes has not, as yet, been satisfactorily attained. The method heretofore in vogue, of measuring on a scale the distance the secondary coil is advanced over the primary, is inaccurate and delusive—in fact means nothing—since the battery current varies with use; and no estimate is taken of the variable resistance encountered in the external circuit, which is altered by the location of the electrodes, their size, and the distance between them. The fact that this current possesses the same two qualities as the galvanic current, *pressure* and *volume*, makes it evident that we must in some manner estimate the relative voltage and amperage of the current employed, in order to arrive at a practical conclusion of its comparative value.

An instrument upon this principle called the Faradometer has been devised by Dr. Wellington Adams, but as yet, it has not been put upon the market. It is placed directly in the secondary circuit with the patient, and arranged so that it may be included, or excluded by withdrawing, or inserting a metallic plug. The plug being removed, the current circulates through the coils of the instrument, and when inserted, the current is switched off by another route, where it exerts no influence upon the needle. Of its action Dr. Adams says: "When the plug is removed, the current passes through the magnets M M (shown on a diagram in his work, Vol. 1, page 104)* thus operating the instrument normally to measure the strength or volume of the current, in fractions of a milliampere, being sent through the tissues, but by adding a suitable resistance and connecting the binding posts to the terminals of the induction coil, at the same time that a current is being sent through the patient, the tension or electro-motive force of the current may likewise be measured directly in volts." The scale is arranged to read up to one milliampere by hundredths, each of the smallest divisions indicating one hundredth of one milliampere.

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*Electricity. Its Application in Medicine. By Wellington Adams, M. D. Published by Geo. S. Davis.

CHAPTER IV.

STATIC ELECTRICITY, AND ITS CURRENTS.

This, which is the oldest form of electricity known, is sometimes called frictional or franklinic electricity. The term static is most frequently employed, and denotes that the agent is restrained in a state of high tension. It differs from the other two currents in possessing a very high electro-motive force but very small volume. A static machine generates a current by reason of a difference of potential which is established by mechanical device. The difference of potential is very high, giving the current thus engendered a voltage running up into the thousands, but, because of the enormous internal resistance of the machine, the volume of the resulting current is very small.

The earlier machines for generating this current consisted of a glass cylinder with a rubber for establishing friction, upon the principle of rubbing a stick of sealing wax with a silk handkerchief; hence the name by which it is sometimes known—frictional electricity. A stick of sealing wax which has been excited in this manner becomes electrified, and when brought near some light body, like a pith ball suspended by a thread or small particles of paper, attracts them until contact is formed when they become charged and are afterwards repelled. The electrified wax is charged with positive electricity and the silk handkerchief, with which it has been rubbed, becomes charged with an opposite or negative electricity. Certain non-conducting materials, such as sealing wax, glass or highly polished hard rubber, can be electrified by friction, or they become electrified (charged) by induction, that is by proximity to a body already electrified. Electrified bodies attract non-electrified bodies, by first causing them to become charged by induction. They also communicate electricity directly to them by contact. A static machine is simply an apparatus for generating electricity upon these principles.

The later machines, such as the Holtz and Töpler, operate upon the principle of induction in producing the current. The former is purely an influence machine, being composed of glass plates or discs arranged so as to generate electricity by their mutual induction. This machine requires an initial charge on the back or stationary plate before it can be operated, which charge acts inductively upon the other revolving plate with increased force. This becoming surcharged, re-acts upon the back plate with great force, resulting in the accumulation of a charge of very high potential. The Töpler machine is arranged for making the apparatus self charging, and cumulative, like the dynamo or electric light generator. This object is obtained by mounting upon the front plate six little round metallic buttons called carriers, and providing upon a stationary apparatus two metallic brushes to rub against them. When the front plate is revolved, these brushes rub against the carriers and generate an initial charge which is conveyed to the inductors upon the back or stationary plate. Such are the principles upon which the modern machines for generating static electricity operate.

Many improvements have been made upon the original apparatus, such as a combination of the two and the substitution of several pairs of plates, every alternate one being stationary and its fellow revolving. Likewise the diameter of the glass discs has been increased so as to lengthen the spark it will give, that is to make it jump through a greater space, since the length of spark which any machine of this kind is capable of giving is equal only to the radius (half the diameter) of the glass discs. The most improved machines have several of these discs arranged in pairs, having a diameter of thirty or more inches. Each pair comprises one revolving and one stationary disc, separated from each other about a quarter of an inch. These plates are perforated with several holes called windows to which are attached pieces of aerated paper which project over the edge of the glass into the windows. These are inductors. Fastened to brass rods on insulated stands are attached brass combs directly opposite these windows, for catching the current when induced. These brass rods project outside of the machine cover, and terminate in large brass balls to which are attached the Leyden jars or condensers. It is necessary to have the apparatus covered with a glass case to keep out moisture and dust which would seriously impair its use. To still further remove any moisture which may leak in, a vessel containing anhydrous chloride of calcium is kept within the glass cover. Upon the brass rods mentioned above, and at a right angle to them, are placed brass bars terminating in balls and arranged so as to slide. When these opposite brass balls touch each other and the machine is set in motion, the current thus generated passes quietly from one to the other, one being positive and the other negative; but when they are separated sparks pass between them. The length of the spark is varied by the relation of these sliding rods or balls to each other, producing a longer or shorter spark according as they are more or less approximated. The two balls in which the brass rods terminate, outside the machine, constitute the positive and negative poles, since one is directly connected with the conductors receiving the positive electricity from the generators, and the other with those receiving the negative.

The Leyden jar is a glass vessel coated both inside and out with tin-foil up to one-fourth of its height, and is used to condense and store the electricity for subsequent discharge; a positive charge being accumulated on one surface of the glass and a negative on the other. By connecting these two oppositely charged surfaces on the outside of the jars, by means of a brass rod or other metallic conductor, a discharge with report and a spark is obtained. To make this clearer, an opposite electricity is induced upon the outer surface when the inner surface of the jar is charged. Morton has named the current derived from these two outer surfaces, the secondary induced current of the static machine.

The machine may be operated by hand-power, water-power, or an electric motor may be employed for revolving the plates.

It will not be necessary in this connection, to enter into a detailed account of the various methods of applying this current for different therapeutic purposes, but some knowledge of the general method of its application will be necessary for a correct appreciation of its utilization in gynæcology, and therefore a brief description of the ordinary methods of administration will be given.

The method known as *static insulation*, or dry electric bath, consists in placing the patient upon an insulated platform connected with one of the poles of the apparatus, the opposite pole being connected with the ground. The brass balls are separated widely and the machine is set in motion. The patient becomes charged with electricity which passes off so gradually that it is scarcely noticed. The Leyden jars may or may not be attached to the brass rods in this instance. The patient is utilized as a Leyden jar, and care must be taken not to allow any object to come near, or a spark will pass and cause a slight shock.

Another method consists in drawing sparks from any portion of the body, the patient being on the insulated stool. There are two ways of doing this, known as the *direct* and *indirect spark.* The former consists in disconnecting the pole from the floor, where it was grounded, and attaching to that pole a chain conductor, to which is fastened a ball electrode in an insulated handle held by the operator, and on approaching some part of the patient's body with this ball a spark will be drawn from it, even through the clothing. This is a very strong application, and much stronger than the indirect spark, which consists in grounding upon the floor the opposite pole from that connected with the platform upon which the patient is seated, and connecting the ball electrode by chain with another part of the floor, or with the gas fixture in the room, thus interposing an extra resistance which modifies the shock.

Still another method of administration is that known as the *static induced current,* the manifestation of which resembles the action of the faradic current. The part to be treated must be exposed, and moist sponge electrodes are applied in the same manner as for the faradic current. One pole may be taken in the hand, or may be attached to a foot plate upon which rests the feet of the patient, while the other is applied to the part to be treated. The brass balls on the sliding rods are now placed in contact, the machine is set in motion, and the balls are separated gradually, producing a rapid succession of impulses which are transmitted to the structures included between the electrodes. The Leyden jars are attached to the brass rods, but the rod connecting their outer covering is removed. As usually employed, the chains or conducting cords of the electrodes are attached to the outside coating of the Leyden jars by the hooks which serve to hold the rod connecting them when it is used. The strength of the current depends upon the distance the brass balls on the sliding rods are separated, and the size of the jars. To Dr. W. J. Morton is due the credit of discovering and naming this current, and pointing out the changes in the machine to produce it, as well as introducing electrodes which render possible the application of this static induced current to gynæcological purposes; and he has done much to establish its therapeutic value in this direction. In a valuable contribution to the New York Neurological Society, in December, 1890,* he presented in a very forcible manner, the claims for its recognition as a therapeutic agent of equal value with the galvanic and faradic currents. In this paper he laid claim to a new system of administration of static electricity, first published in 1880, which comprises the development of a rapidly interrupted and graduated current, by means of a circuit breaker, either with or without condensers, and in its application within or without the human body, by moistened sponge or other electrodes, just as in employing the galvanic or faradic currents. The spark is removed to some distant part of the necessarily closed circuit, and is no longer a direct feature of its administration, though all the physiological effects of the current are retained.

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*Medical Record, January 24, 1891.

The circuit-breaker is either the approximated discharging rods above described, or may consist of a pair of adjustable metallic ball electrodes (Morton's pistol electrode, Fig. 20) having a small air space be-

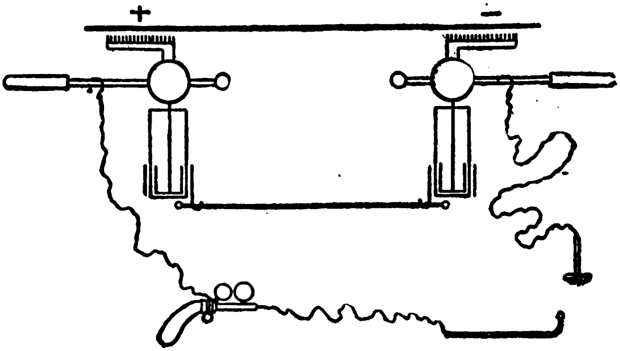

FIG. 18.

Static Universal Electrode, with Condensers. Otherwise same as Fig. 20, but the current is more powerful. Small condensers are preferable.

tween the balls which can be varied. This may be introduced at any point of the circuit. The current makes when a small spark overcomes the resistance of the intervening air space, and breaks when it fails to do so, and the current is due to rapidly successive equalization of the differences of potential of oppositely charged condensers.

He claims for this circuit breaker:

1. "That time is afforded for the prime conductors and condensers, if used, to charge."

2. "That it serves to regulate the frequency of the discharge, and collaterally the frequency of the successions of transient currents, so that their aggregate may be classed as a steady current."

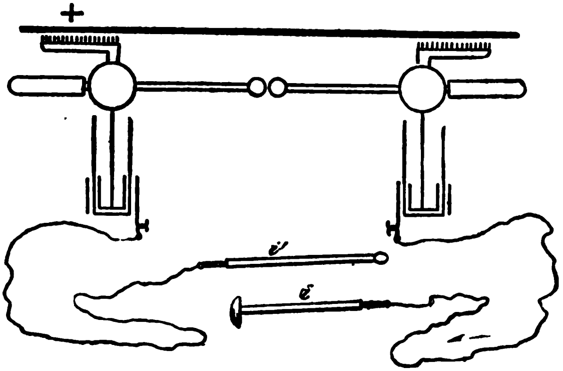

Fig. 19.

Diagram Illustrating Connections for Internal Treatment by the Static Induced Current. *i*, Indifferent electrode; i^1 uterine or other interior electrode.

3. "That it determines the strength of the current which may be varied at will and with the utmost nicety, from a just perceptible to a most powerful effect."

The variation of effect is accomplished by means of a device upon the principle of the pistol electrode by which the balls may be very slowly separated. This interrupting device may be placed anywhere in the circuit, and the same electrodes that are used for faradic applications may be employed. It can be arranged as a moveable electrode to be held in the hand, or may be fixed to the cabinet or the couch upon which the patient reclines, wherever it is most convenient for the disengaged hand of the operator. Dr. Mortons finds in practice that his static induced current produced by condensers, and the discharging rods used as a circuit breaker, is the most serviceable, Fig. 19.

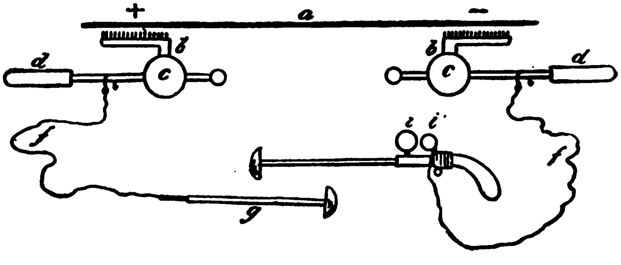

Fig. 20.

Static Universal Electrode. Interrupted primary circuit of a Holtz Machine without condensers. *i*, *i*, Static universal electrode in circuit.

It is claimed for the *static induced*, or *Franklinic interrupted current*, that it possesses all the physiological attributes of the faradic current, and that it may be employed for the same purposes, since the impulses may be varied for producing muscle stimulation and contraction, or sedation in the same manner as the faradic current of high tension from the fine wire coil. In fact the oscillations are far in excess (reaching millions per second) of anything afforded by the most rapid vibrator of the faradic apparatus. When we take into consideration the fact that what we are striving for in the faradic machine to effect satisfactory sedation is an increase of its tension or electro-motive force at the expense of the volume of the current, it will be seen that it is but an effort to approximate what we already have in the static induced interrupted current, and the claim urged for its substitution can be appreciated.

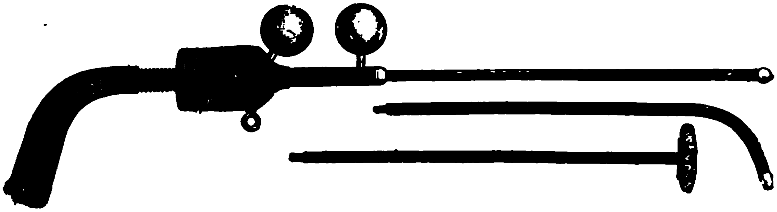

Fig. 21.—Dr. Morton's Static Universal (Pistol) Electrode.

Though the capabilities of this current in gynæcology may be regarded as only suggestive, since clinical demonstration is as yet lacking, we can see no reason why it should not be just as effective in this direction as in others, upon the external surface of the body for instance, where there is abundant evidence in its favor. Of the physiological properties of this current Dr. Morton says that it produces the most vivid and persistent muscular contraction with a minimum of pain, as compared with the current from faradic coils, and the influence is remarkably diffusive. Accompanying the contractions which are painless a peculiar sensation of buoyancy is experienced. One of the most prominent characteristics of this current is its power of relieving pain which is promptly manifested, particularly in certain neuralgic conditions.

The author has had only a limited clinical experience with this current in gynæcology, but a personal acquaintance with Dr. Morton, who has so persistently urged its claims as set forth above, leads him to believe that it deserves more consideration than it has heretofore received. Apart from his rare attainments as a neuralogist, he is one of the most accomplished medical electricians of the day, and consequently has a thorough appreciation of the subject from every standpoint.

It will be unnecessary to take up space with illustrations of the numerous electrodes used in connection with this current. They are to be found in the illustrated catalogues of almost every manufacturer of medical electric apparatus. In addition to the current devices referred to above, as the pistol electrode and the approximated discharging rods with Leyden jars, one other especially designed for the internal administration of sparks in gynæcology should be mentioned. As shown in the cut, Fig. 22, it consists of a glass cylinder completely closed, except a very small opening where it comes in contact with the vaginal surface through which the spark is drawn. Within this glass cylinder there is a brass ball attached to a sliding rod, which is manipulated by means of a guiding handle. It is quite necessary that the cylinder should have only a very small opening for the transmission of the spark, for the vagina being a moist cavity the undue amount of moisture admitted through a larger opening would prevent spark manifestation. Therefore, the end of the cylinder must not be left open, as shown in the illustration of a supposed modification of this electrode in a recent work upon this subject. Furthermore, the modification possesses no novelty, as it was published by the French writer Mauduyt in 1784 as an ear electrode, having a fine wire inside of the open end glass cylinder, instead of a ball inside the cylinder, and perforated disc end, as in Morton's director.

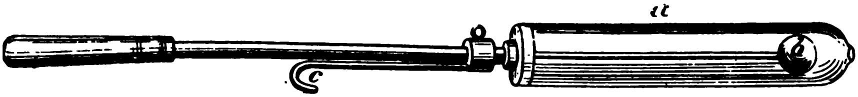

Fig. 22.—Dr. Morton's Static Spark Vaginal Electrode or Spark Director.

b, Electrode ; *a*, insulating tube perforated for passage of spark and currents; *c*, guiding handle for regulating length of spark and currents.

The main drawback to a more universal application of this current for therapeutic purposes is the expense of the necessary apparatus and the space it occupies, which is by no means an unimportant factor in its unpopularity. Until these objections can, in a measure, be removed its use will certainly continue to be limited.

Very recently the small static machine shown in Fig. 23 has been introduced for charging the larger machines. Its reasonable price and small size would

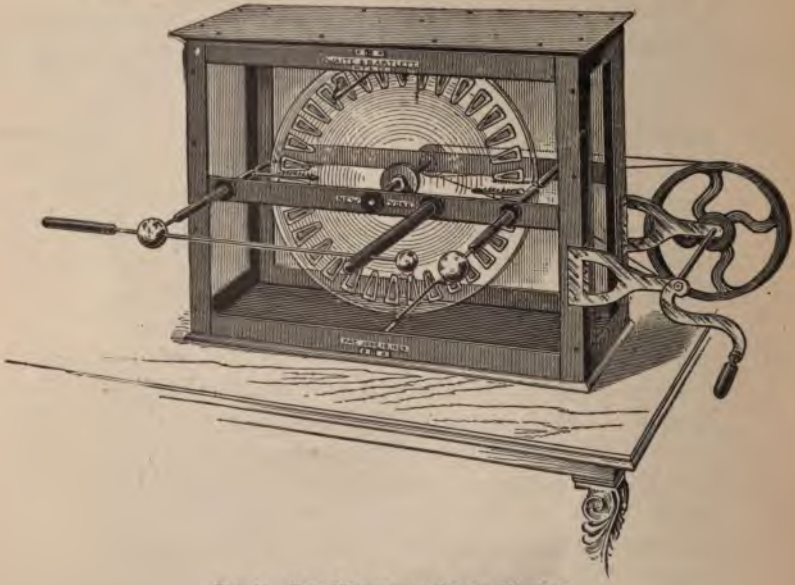

Fig. 23.—The Wimshurst Static Machine.

obviate the objections just mentioned, and it may be the means of establishing the value of the static induced current in gynæcology upon a surer footing. Its cost does not much exceed that of a good portable galvanic battery. It may be operated by hand power, but a water, gas or electric motor would be more convenient. The current is not produced so rapidly as in the larger machines, but it has proved sufficient for gynæcological purposes in utilizing Dr. Morton's induced current; and the machine possesses the advantage over the larger machines that it will give a current in all conditions of atmospheric surroundings. It consists of two glass discs placed near together, which are made to revolve in opposite directions by means of belts attached to the spindles outside the glass case inclosing them. Upon the outer margin of these discs are placed brass "carriers," which in revolving are rubbed by metallic brushes arranged within the case. Metallic combs are placed on either side for collecting the current, which is conveyed to the brass balls on the outside.

If the plates are revolved rapidly, the current is produced with sufficient rapidity for practical purposes. In using this current in gynæcology, the same electrodes may be employed as for the faradic current. The conducting cords are attached to the hooks connected with the outside coating of the Leyden jars (the connecting rod being removed) when it is desired to use the static induced current. For producing the interruptions, the pistol device may be introduced into this circuit with the patient, the sliding rod between the brass balls or poles of the machine being widely separated; or the interruptions in this the secondary circuit can be produced by breaking that of the primary by means of the sliding rod. This will be readily understood by referring to to the diagrams, Figs. 18 and 19. Fig. 20 illustrates the employment of the primary current without the jars, by means of an interruptor placed in the circuit with the patient.

CHAPTER V.

APPARATUS.

Cabinet Batteries or Stationary Apparatus.—The question is often asked, what form of cabinet is the best? The best is always the most desirable and satisfactory, but it is also the most expensive. One who is doing much work with electricity should possess the best apparatus obtainable, and he can ill afford to have anything else, though it is not by any means necessary to possess the most expensive apparatus in order to be able to do good work. For one of limited means to get up an outfit, a number of cells, say thirty or forty, set up in any convenient place, and the two terminal wires of the series, positive and negative, running to two binding posts (marked + and —) placed in a convenient location on the wall will be quite sufficient. An ordinary table on which is placed a rheostat or current regulator and a milliamperemeter, the conducting cord from one binding post to be passed through both, then to the patient, and the other passing from the other binding post direct to the patient, will form a complete and economical apparatus for galvanic work. It may be convenient and desirable to have a pole-changer attached to the table also, and this should be so arranged as not to short-circuit the current when the change is made.

No cabinet is complete without a suitable and reliable rheostat through which to regulate the current. The cell selector should not be used for turning the current on or off, as every time a new cell is added or taken off a short circuiting is produced which will prove injurious to the cells. The only real value of the cell-selector is to enable the operator to use any number of cells desired through the rheostat, and thus avoid the necessity of using the whole series every time, which would be objectionable if a weak current was desired. In every instance the necessary number of cells should be turned on beforehand and the current regulated by the rheostat. The only real advantage then of the cell selector is to limit the number of cells to be used through the rheostat. This is, by no means, an insignificant advantage for general work, since with the best regulated rheostats it is quite impossible to employ a·mild current satisfactorily from all the cells used at one time.

This fact has led the author to suggest the construction of a table top or switchboard arranged with a series of switches, so that five, ten, fifteen, twenty or any number of cells may be turned on at any time to be used throught he rheostat. By such an arrangement economy is secured, and the advantage of the cell-selector is substituted. Only four switches will be needed for a battery of thirty cells and only five for forty cells. The arrangement would be for five cells on either side and three switches of ten cells each in the middle, thus:

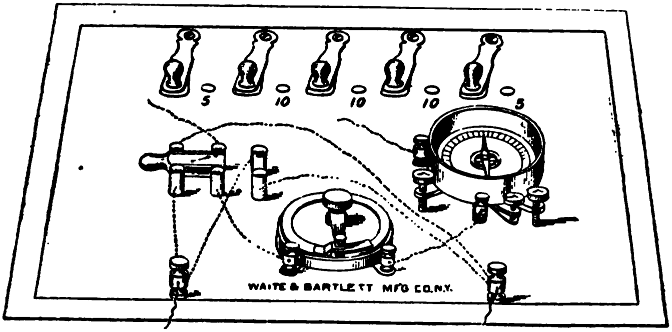

Fig. 24. — Author's Switch Board with Pole Changer, Rheostat, and Milliampere Meter.

One disadvantage of this arrangement is that it will require more wires to be run from the cells than with the first described arrangement, where all the cells are worked together through the rheostat, in which case only two wires are necessary ; but it will necessitate fewer wires, by far, than the usual cell selector. The cell-selector necessitates a wire from every cell in addition to the terminal wires from the series, making forty-one wires for a battery of forty cells. The other arrangement by switches requires only six wires for forty cells, and if the battery is arranged to combine all the cells to be used through a controller, only two wires are necessary.

It will, of course, be understood that there is no intention to belittle the conveniences of the best cabinets where everything is combined on one board, including in addition to the cell-selector, pole changer and switch for turning the current on and off, an appliance for interrupting the galvanic current, and switches for resistance coils, useful for measuring resistances in scientific investigations, besides the faradic coil and apparatus. The advantage of having the cells in a cabinet, where they are readily accessible in case any of them become impaired, is not to be ignored.

In regard to the number of cells necessary in a battery for gynæcological work, forty are quite sufficient, provided they are of proper construction and will give an electro-motive force of 1.5 volts each, and have an internal resistance of only one ohm.

When it is desired to use all the cells together through a rheostat or controller, they are connected as follows, viz., the carbon of the first cell is connected with the zinc of the second cell, the carbon of the second to the zinc of the third, and so on throughout the series. Then the two terminal wires from the zinc of the first cell and from the carbon of the last are run to two binding posts, placed in some convenient location on the wall, and marked — and + respectively. So long as the meter and controller are placed in the circuit between the two binding posts, it is immaterial where they are situated. It is purely a matter of choice and convenience. Both may be placed on the wire leading from either pole to the patient, or the meter may be placed on one and the controller on the other.

If a key-board or cell-selector is used, the cells are first connected up in series, in the same manner as described above, then the terminal wire of the first cell, from the zinc, is run to the first button on the key-board, marked usually O, and a wire from the carbon of the same cell is run to the button marked 1. For all the other cells in the series, a wire is run from the carbon element to the other buttons on the board, following in order, after 1. (See fig. 25.) A wire runs from the post labeled 19 to one binding post, and another from the lever, labeled 18, to the other binding post marked 13. The socket attachment at 20 is movable, and can be placed on the plug of any cell of the dial, so as to begin with any cell in the series.

Every physician who attempts to use electricity should understand clearly how his cells are set up or arranged, and should be able to do the work himself, in case of necessity, when a practical electrician is not at hand. Besides such knowledge will serve him well in case the battery gets out of order and is not working satisfactorily. Instead of disappointing his patients, and waiting for days or weeks, as sometimes happens, for an electrician to repair it, he can do the work himself. He should also be able to tell when

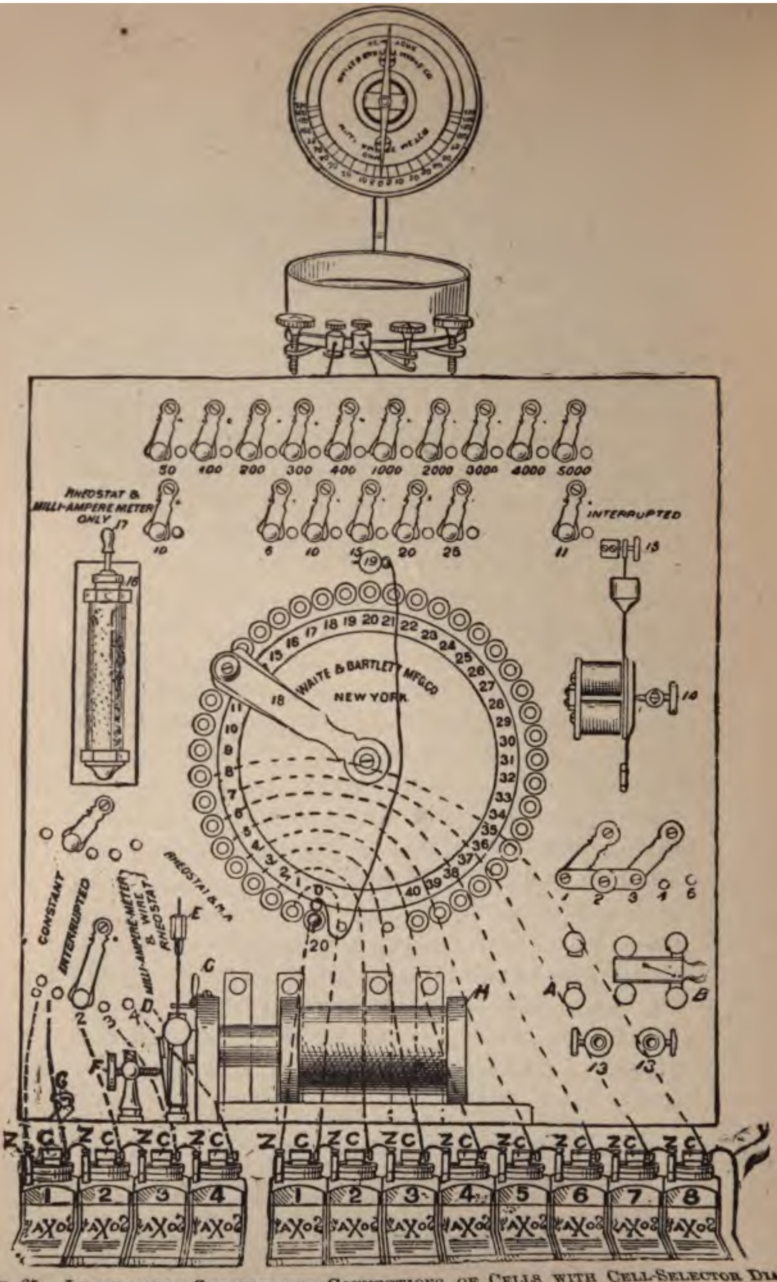

Fig. 25—Illustration Showing the Connections of Cells with Cell-Selector Dial

the battery has been set up correctly, and if the work has been done well.

Test of Polarity.—All batteries should be tested for their polarity before being used for the first time, as it sometimes happens that they have been set up wrong or labeled wrong by the workmen engaged in their manufacture. To do this most conveniently, place the two metallic terminals of the conducting cords from each pole in a vessel of water, and turn on the current. Decomposition of the water will immediately take place if sufficient strength of current is employed, and bubbles of hydrogen will form around the negative pole. With a strong current bubbles of oxygen will likewise form around the positive pole, which may lead to some confusion; but the hydrogen will be the first set free, and by observing from which surface the bubbles first occur the negative pole can be determined. Another test for determining the poles of the galvanic current, is the iodine test. Into a solution of iodide of potassium both poles are placed and the current is turned on. Iodine is set free at the positive pole. The ordinary metallic tips of the conducting cords will answer if care is taken to prevent the cord from coming in contact with the solution. Better still are two platinum electrodes, which are not injured by the iodine.

Pole Changer.—This is a device by which the direction of the current may be changed without changing the electrodes or conducting cords. It will be unnecessary to describe the many mechanical devices for accomplishing this end. It is usually placed in some convenient place on the key-board, so that the polarity of the binding posts to which the conducting cords of the electrodes are attached may be changed at will. By referring to fig. 24, it will be seen how the change of polarity of the binding posts is accomplished, as the arrangement of the wires is shown by the dotted lines. The movable arm marked with the arrow is made of hard rubber, which separates and insulates the two metal surfaces, forming a connection with each of the two central posts.

Connections.—All connections should be as perfect as it is possible to make them, so as to offer no resistance to the current, and when they occur outside of the battery they should be protected from the moisture and dust. When the cells are connected up by means of ordinary covered and paraffined copper wire, the ends should be stripped of their covering and scraped to remove the paraffin adhering to the surface before being attached to the cell. (The cells made by the Leclanché Battery Co., of New York, have these connections made of a strip of pure tin, which resists corrosion for a long time and is sufficiently pliable to allow movement of the cells when necessary.) The same precaution must be observed in cleaning the wires when a connection is to be made in the circuit, and when it occurs along the course of the wire the point must be protected from the moisture and dirt to prevent corrosion, which would cause a break in the circuit, or an imperfect connection, which would offer an unnecessary resistance. This is usually done by wrapping the point where the wire is joined with a specially prepared rubber-coated cloth, which adheres readily. A piece of small rubber tubing will answer as well if it is fastened at each end tightly around the wire.

Wires should not lay in contact with each other where they are confined, as where they pass through an opening or hole. It is better to have each pass through a separate opening, and they should be separated throughout their course as much as possible.

The Rheostat, Current Controller or Regulator.—This is an appliance which, interposed in the circuit with the whole force of the battery or all the cells turned on, gives the operator perfect control of the current and renders it possible for him to increase or diminish it very gradually, thereby avoiding the disagreeable sensations to the patient that are sometimes produced when the current is increased cell by cell. It interposes a resistance in the circuit which, by being gradually diminished, allows more current to flow, the resistance being greater at the start and least at the finish. By its use, the whole or any number of cells from the series may be used at once, the resistance being diminished only to the point that allows the desired number of milliamperes of current to pass. An additional advantage in its favor is, that the cells are used up evenly and the whole series is brought into use every time, and there is no short circuiting of the cells, as when the cell selector is used for modifying the current. The current can be regulated with perfect certainty, and can be increased or diminished very gradually with absolutely no chance of producing shocks. The exact strength can always be obtained, and the patient will bear the gradual increase with more comfort and will be able to endure a stronger current (especially if she is nervous) than when the current is increased by adding cell by cell. With the cell-selector, every cell added makes such a sudden increase in the strength of the current (particularly when the cells are new) that it is often decidedly unpleasant when a sensitive and delicately organized patient is under treatment, as the current strength is frequently increased five or ten milliamperes by the addition of another cell. This is the more readily appreciable when using one electrode bare or uncovered, as is often done in the uterine cavity; and it is also quite noticeable in using the covered vaginal electrode, because the ready conductibility of the moist vaginal surface offers very little resistance to the penetration of the current.

The rheostat is used mostly for the galvanic current, and it may be said to be indispensable where satisfactory work with this current is desired. It may be, and often is, used to advantage with the faradic current also, being interposed in the secondary circuit. The advantages of its use in this connection were mentioned in speaking of the induced current.

The Bailey water rheostat (old form) is a large jar half filled with water, covered with a cap through which a notched rod passes, and to which a thumb wheel and ratchet is affixed. Attached to this metal rod within the jar are two pairs of carbon plates insulated from each other, each pair being connected with a separate rod running parallel with the central rod, and terminating in a binding post for connection with the wire from the battery. The carbon plates are made pointed as they enter the water and a piece of sponge is attached to the extremity of one plate on each side. An improvement upon this has been suggested by Dr. Wellington Adams, of St. Louis, viz: a small hole is drilled into the point of the carbon plate and a piece of graphite from a lead pencil is inserted to take the place of the sponge. In this instrument the current must pass through the water intervening between the two pairs of carbon plates as they are lowered into it by means of the ratchet arrangement on the cover of the jar. When the plates and points are out of the water, no current passes, and as they are lowered into the water, the distance between them is gradually diminished and with it the resistance. But when they are completely immersed there is still a resistance of from ten to twenty ohms. The instrument possesses some serious defects. The metallic connections with the carbon soon corrode, creating a high resistance and finally a break; and the condensation of the moisture within the jar upon the insulating material separating the plates, forms a medium of connection between them which allows some current to flow before they touch the water. A very serious objection is that the ratched or cog-wheel arrangement, for lowering and raising the plates, will wear, become loose, and they will sometimes drop suddenly into the water if the hand is removed from the wheel which manages it; an accident which would produce a very disagreeable shock. It, is however, the best water rheostat in the market. The current can be regulated at the start to a nicety not possible with other instruments of this kind, and this can be accomplished with full battery strength of 100 cells, though when the second plate of each pair, which has no sponge tips, touches the water, there is generally a jump of several milliamperes, which would be objectionable in some instances; but this might readily be avoided by pointing the extremity of these plates also. It is in no sense a portable rheostat, however, and should be fixed in position to avoid upsetting. In addition it is awkward and unsightly. It cannot be considered very convenient for the operator to manipulate, and should a rapid removal of the current become necessary it cannot be accomplished so readily as with some of the other forms of rheostat to be described.

The Law Telephone Co., who make the Bailey rheostat, have abandoned the one just described, in favor of a new form shown in the cut. Instead of four carbon plates there are but two, so arranged that by means of a thumb screw they may be sepa-

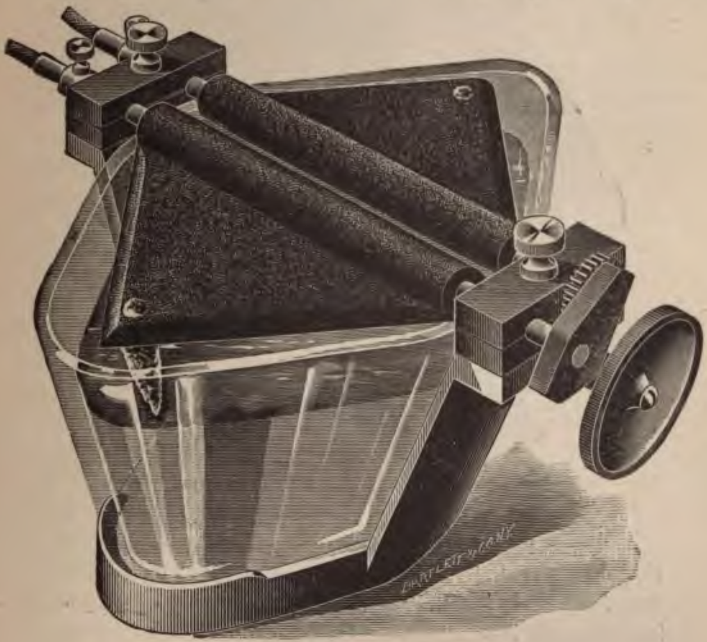
BARTLETT & CO. N.Y.

Fig. 26.—The New Bailey Rheostat.

rated to the extent of complete removal from the water, or brought together, removing all resistance. There is an immense resistance when the sponge tips just touch the water, which affords perfect regulation of the current from a large number of cells. The illustration is one-third the actual size.

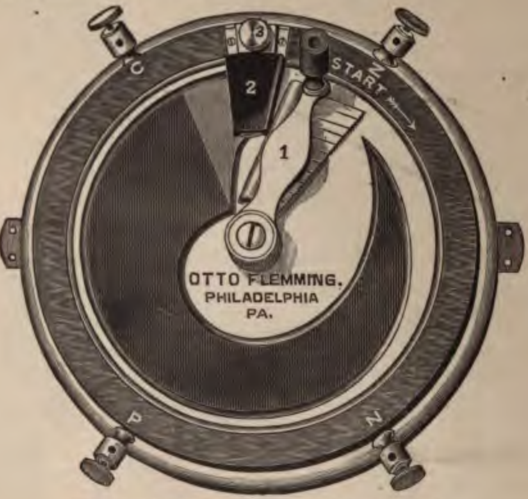

Fig. 27.—The Massey Current Controller.

The Massey Current Controller is a modification of the old Butler rheostat, introduced by Dr. Butler, in 1880. Its resisting medium is a light coating of graphite or pencil lead rubbed on a flat disc, which coating narrows down from a broad base to a point. As constructed by the original maker, Otto Flemming, of Philadelphia, for Dr. Massey the disc is of marble and the surface for the coating of lead is marked out by a groove cut in its surface. The base of the penciled surface where the metallic connection is made, is nickel plated, and the connection is made by spring pressure directly upon the plated surface, the whole connection being covered by a cap of hard rubber fastened down tightly to protect it. The plated surface projects out beyond this cap on the surface of graphite coating, and is coated over with the graphite making the connection with it perfect. As modified for the author by the Waite & Bartlett Mfg. Co. the disc is made of slate with the cone shaped surface roughened for retaining the graphite coating. The advantage of the slate is that it does not become soiled like the marble, and it always presents a neat appearance. The brush for moving, over the resistance surface is made of spring brass nickel plated, sufficiently broad to span the broadest part of the leaded portion, and the spring is split up in several places to insure perfect contact over the entire surface upon which it rests. One of the binding posts attached to the wooden frame surrounding the disc connects with the base of the leaded surface by means of the spring contact under the cap, and the other with the central pivot to which the brush is attached by a lever; so that there is a break, so to speak, between the two when the brush stands at the point marked "start" removed from the coated surface. As the brush is moved up on the graphite the resistance is diminished the nearer it approaches the base. The graphite, which is really a good conductor of the current, when spread out over a flat surface like this offers considerable resistance. In order to increase the resistance at the start, so as to permit the current to be turned on gradually from a battery of a great number of cells, it is necessary to make the graphite coating very much thinner there than elsewhere, and if too much has been put on, it should be rubbed off until its presence is scarcely perceptible at and near the starting point. The only objectionable feature about the instrument is the perishable character of the graphite coating, which is being constantly rubbed off by the brush, but it is easily renewed by rubbing over the surface a carpenter's lead pencil, or in fact an ordinary pencil, but the former having a larger surface of lead, the coating can be renewed more rapidly. It is possible with this rheostat to gradually remove the entire resistance by moving the brush up over the surface which has been covered with graphite, or at least the remaining resistance is so little as to be inappreciable.

The advantages of this rheostat are that it is flat, it occupies a very little space, it cannot be upset, and the connections are practically indestructible. It can be readily removed from the cabinet or table and transported for use elsewhere, though its size (the diameter being about seven or eight inches) makes it rather an awkward instrument for carrying conveniently in a bag.

Recognizing the fact that a smaller rheostat for use with a portable battery at a patient's house—one which would be small enough to make a convenient package or that could be carried in the pocket from place to place—would be desirable, the author was led to suggest the modification of this rheostat shown in the cut, figure 28, which is made for him by the Waite & Bartlett Mfg. Co. It is a small disc of slate, only three inches in diameter, marbleized on the upper face, and around the side. Around the margin of the upper face is a raised surface about one quarter of an inch wide, not marbleized but roughened for receiving a coating of graphite. The connections

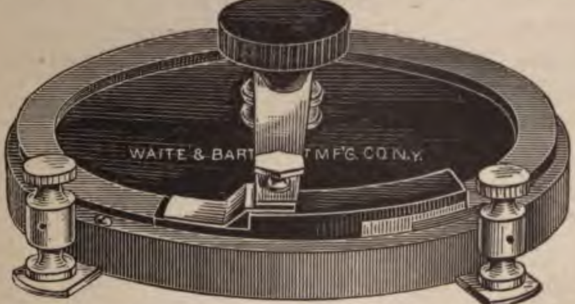

Fig. 28—Author's Slate Pocket Rheostat for Galvanic Current.

are made in the same manner as in the Massey instrument. The contact of the lever with the graphite surface, is made by a small wheel, ground to fit the raised surface which is made level, and in front of the wheel is placed a projecting spring pressure foot, like that on a sewing machine, to which is attached a piece of graphite for constantly renewing the coating. The object of the wheel is to make it move more smoothly and to avoid sudden jerks. The lever is turned by a thumb screw fixed to the pivot passing through the center of the disc, and can be manipulated with greater ease than the other instrument. This rheostat is small enough to be carried in the vest pocket and is very useful and efficient. It can be used with forty or fifty cells as satisfactorily as the other instrument, but the same care must be observed not to have the graphite coating too heavy at the starting point. Nearly all the resistance is cut out at the finish. A larger size is made but it is not so convenient.

Fig. 29 represents a rheostat recently introduced by the Chloride of Silver Dry Cell Battery Co., of Baltimore, designed by Mr. Charles Willms, of the firm. The resisting material, consisting of common glue, graphite and metal filings (brass preferred), is placed on the under surface of the top plate; the graphite being really the resisting material, the brass filings collecting the current and conducting it to the metal contact points leading to the surface, where the turning crank forms a connection with them.

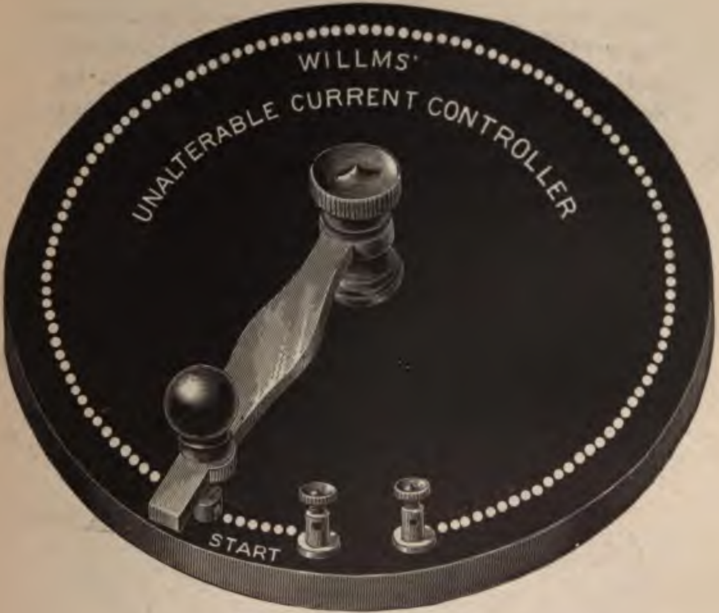

Fig. 29.—Willm's Rheostat.

The rheostat shown in Fig. 30 was devised by J. C. Vetter & Co., of New York. It is small, convenient, and a very satisfactory instrument. The principle of construction is the effect of variation in resistance, which takes place in carbon with a change in pressure. A quantity of specially prepared carbon in a finely divided state is placed in a small rubber pouch or cylinder, which is enclosed by two metal plates to which the two sides of the circuit are connected. The lower plate is fixed to the base of the instrument, and the other, traveling in upright guides, can be depressed by means of a screw with a fine thread, so as to compress the carbon in the rubber cylinder. In this way, the current passing can be adjusted with the greatest nicety. The variation in the resistance of the rheostat follows the movements of the screw through very wide limits, thus controlling from off or no current to the full capacity of the battery.

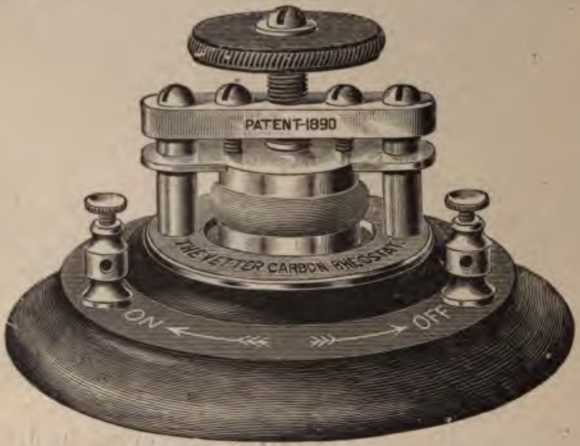

Fig. 30.—The Vetter Carbon Rheostat.

To introduce any of these rheostats into the circuit, the battery wire from either pole is attached to one binding post and another wire attached to the other binding post leads to the patient. Some of the Massey rheostats are made with four binding posts for the purpose of avoiding confusion in connecting the instrument with the battery, but this precaution is entirely unnecessary. The two binding posts on the left, marked C at the back and P at the front, are connected directly with each other by a wire running under the bottom of the frame, while the other two are the same as described above.

Fig. 31 represents a switch-board introduced by de Watteville, of London, for combining the galvanic and faradic currents for simultaneous administration. The conducting cords from the galvanic battery are attached to the binding posts on the left, marked G, and those from the secondary coil of the faradic battery are attached to the posts on the right, marked F. A combination switch is arranged between these, which when turned towards the side marked G. furnishes the galvanic current only from the binding posts on the front of the board to which the conducting cords leading to the patient are attached. When this switch is turned to the other side marked F. the faradic current only is obtained from the front binding posts. But when the switch stands straight in the center, between the galvanic and faradic posts, a combination of the galvanic and faradic currents is furnished from the front posts. A pole changer is placed a little in the rear and between the front binding posts. The strength of each current is varied in the same manner as in administering each current separately.

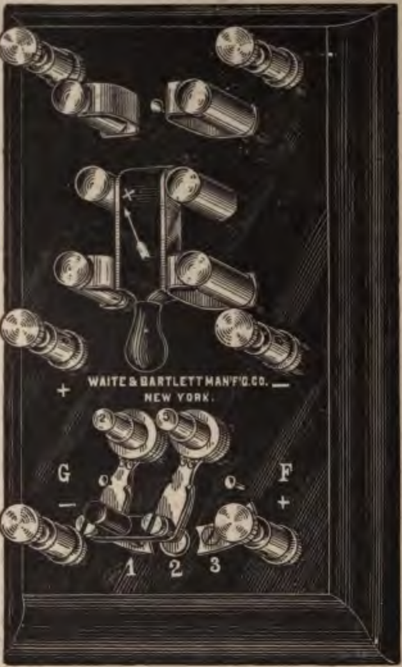

Fig. 31.—De Watteville Switch-board for the Combined Galvanic and Faradic Currents.

In the absence of this switch-board, which is very convenient and satisfactory, and should be placed upon every cabinet apparatus, the combination may be brought about by connecting one pole of the galvanic battery (from binding posts) to the opposite pole of the secondary faradic (at the binding post for that current) and attaching the electrode cords to the two remaining binding posts, which will constitute one galvanic binding post and one faradic. That is, connect the negative post of the galvanic battery with the positive of the faradic; then connect one electrode with the remaining galvanic post, which will be the positive, and the other with the remaining faradic post, which will be the negative.

De Watteville employs this combination to secure a greater penetration of the faradic current for certain deep-seated painful conditions, which are not affected by this current employed alone because of its superficial action. It is particularly adapted for application to the abdominal organs.

The Milliampere Meter.—The meter is a delicate piece of mechanism introduced into the circuit for the purpose of measuring the current strength or intensity of the galvanic current. It is beyond the scope of the present work to describe the mechanism of the different varieties of these measuring instruments, and it will only be necessary to say that those in general use are of two kinds—one depending upon the influence of the earth's magnetism to hold a magnetic needle, swung horizontally upon a frictionless pivot, at the zero of the scale, and the current passing through a coil of wire arranged near it, causes a deflection to the one side or the other according to the direction of the current; the other depends upon the influence of a permanent fixed magnet. A third variety, but little used now, depends upon the influence of gravity.

The one which depends upon the earth's magnetic influence is subject to variation according to location, because there is a variation in the earth's magnetism in different locations on the surface of the globe, hence an instrument of this kind which would register correctly at the place where it is made (for instance in some foreign country) may not be accurate if used elsewhere, if there is a difference in the magnetic influence between the two places.* The one depending upon the influence of a permanent magnet is not influenced by this variation, but all magnets are apt to deteriorate in power, and lose, in a measure, their influence, and for this reason meters constructed upon this principle become inaccurate in time; nevertheless these difficulties may be overcome by having them recalibrated or corrected at intervals to insure their accuracy.†

Until very recently, these instruments have been open to a more serious objection, viz.: that it was difficult to find any two that would register alike, and in some the discrepancy was considerable. The discovery of this fault led the author, about a year ago, to investigate the cause and endeavor to have it rectified. He called together all the meter manufacturers of this country and invited them to bring their most accurate meters with them for a test. All but two responded and showed a desire to aid in establishing a uniform standard of measurement. All the meters manufactured in this country, including those made by the two firms who absented themselves (their instruments being secured from physicians who had them in active use), were put to a practical test with those of foreign make, which included the Gaiffe and Eidleman. There was considerable variation in some of the instruments. This was accounted for by the fact that some had used the B. A. unit of resistance for calibrating, while others had used the *legal ohm.* This difficulty could be overcome by adopting the *legal ohm* as the standard unit of resistance. A resolution to this effect was adopted, which will hereafter secure uniformity of measurement, at least in the meters manufactured in this country. The author has the written assurance of all the manufacturers, including the two firms referred to above, that this resolution will be adhered to in the future, so that a comparative degree of accuracy may be depended upon now. In the present state of the question there is no choice in regard to any of these instruments except in the matter of design. They all are or should be accurate.

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*The difference is really so slight as to be of little moment

†Meters which have a permanent magnet in the controlling field will read higher as the magnet deteriorates.

If any two are discovered that do not agree, they should be sent to their respective makers with a demand for recalibration (correction).*

Meters depending upon the earth's magnetic influence are subject to less variation, and are to be preferred for this reason, but they require very careful handling, and must be set perfectly level. Those with a perpendicular needle depending upon a permanent magnet are more portable and more easily adjusted.

The dial or scale should be marked separately for each individual instrument. In other words the dial should be made or marked according to the deflections of the needle, and not stamped out before, and the needle adjusted to it. Meters with shunts for magnifying the readings of the scale are not as reliable as those with direct reading scale.

A cut of both varieties of meter have been introduced. Fig. 32 represents a milliampere meter with horizontal needle, and Fig. 33, the same instrument with perpendicular needle.

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*At the recent meeting of the American Electro-therapeutic Association a committee was appointed to confer and decide upon a plan which would bring about a more uniform standard of registration. It was suggested that every meter should be sent to some scientific institution to be tested and registered before being put upon the market; a certificate of accuracy or corrections to be furnished with each instrument as with Yale tested thermometers. This will increase the price of these instruments somewhat, but the purchaser should be willing to pay this additional cost to have an accurate measuring instrument.

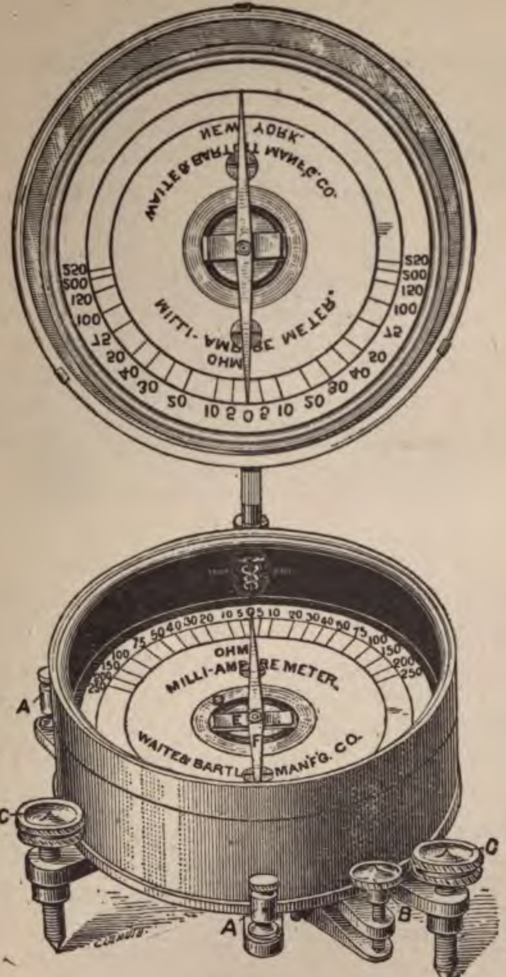
NEW YORK.
WAITE & BARTLETT MANF'G. CO.
MILLI-AMPERE METER.
OHM
WAITE & BARTL MANF'G. CO.
A
A
B
C
C
E
F

Fig. 32.

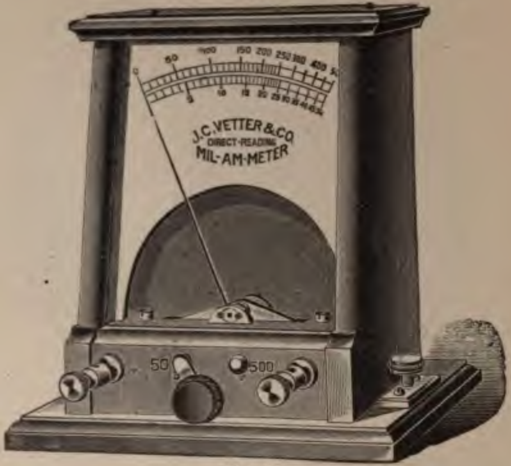

Fig. 33.

THE ELECTRODES.

External or Indifferent Electrodes.—Many attempts have been made to substitute something better, or improve upon the Apostoli clay electrode, so as to do away with some of its supposed objections. As used by Apostoli it is certainly objectionable, being inconvenient, uncleanly, and troublesome to keep in condition ready for use. As pictured in catalogues of electrical manufacturers in this country it is not as he uses it. He has a flat, moist cake of modeler's clay, the consistence of putty, round and irregular in outline, about three-quarters of an inch thick, inclosed in a piece of gauze. The metallic plate, which is of sheet block tin, about 3½ by 5 inches, is placed on the back, partially imbedded in the clay, with wire connection permanently attached (soldered). This is laid on an ordinary towel with the plate side next to the towel. The other smooth side, with no covering except the gauze, is applied to the surface of the skin. After awhile the meshes of the gauze become imbedded in the clay, and the pad appears to have no protective covering. The object is to apply the clay evenly to the whole surface, so that it will adapt itself to all the irregularities of the surface, making a perfect contact. Unquestionably this is the most perfect electrode of its kind yet introduced, in that it allows the use of the strong currents necessary with a minimum amount of inconvenience to the patient. It is not necessary to make one fresh every day, but it will need frequent renewal.

The author has introduced a modification of this electrode, which is free from its objectionable features, and believes that an experience of more than three years' constant work with it, justifies him in saying that it is as near perfect as can be desired, and in every way satisfactory. A cut of this modified Apostoli clay electrode is shown in Fig. 34. Clay has been adhered to as a basis of its composition, because it is believed to be more satisfactory in every respect, than any other material. It is of considerable importance that the clay should be of good quality. Ordinary clay will not answer, being too friable, and not sufficently dense and adhesive. Sculptors' clay, which has been especially prepared for modeling, and which can be manipulated like putty, is the only kind fit for the purpose. The white clay is preferable. This can be obtained from any dealer in artists' materials, and is furnished by Devoe & Co., of this city. It can be ordered through any druggist. I am thus particular because I insist that the user should make his own clay electrodes or have them made under his supervision. In that event it will be necessary for him to know just how they should be made. The material is usually furnished in a plastic condition ready for use, but in transportation, from being exposed, it will dry out, and will sometimes come to hand dry and hard. When in this condition, wrap it up in a wet towel, and keep it constantly wet until of the proper consistence. It may take several days, and it may be necessary to crack off a small piece, about the size desired, so that the moisture can more readily penetrate to the interior of the lump. When of the proper con-

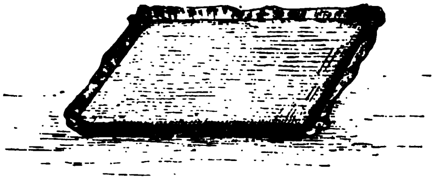

Fig. 34.—Author's Clay Electrode.

sistence, it is to be moulded and worked into a flat cake, and then placed on an even, flat surface and rolled with a rolling pin (such as used for dough) until it has a uniform thickness of three-quarters of an inch. The desired size is then cut out of this cake with a knife. Place under it a thin layer of absorbent cotton, which will reach over the edge all around and lap over on the back. Before adapting the cotton to the back surface, place the metallic plate upon it and press it into the clay until it adheres. This plate, which is of block tin, should be perforated with numerous holes, to facilitate adhesion to the surface of the clay. Thin sheet lead makes a very good plate, being nearly as pliable as the block tin, but for general use the woven brass wire gauze is perhaps the best. Its only disadvantage is that it is springy, being flexible but not pliable, and the electrode will not adhere to an irregular surface, unless constant pressure upon it is maintained. The same objection does not hold with the block tin plate, which retains any shape given it. After the metallic plate is applied, the clay cake, with cotton covering, is lifted up, and a piece of absorbent gauze, or surgeons' lint with the smooth side down, is spread out evenly and the cake placed upon it. This, which is to form a covering, is lapped over on the back (over the plate) and sewed on neatly. There should be no seams or irregularities on the under surface which is to come in contact with the skin. A perforation must be made for the connecting cord or wire through this covering. When finished, the upper side or back of the electrode is covered with rubber cloth or sheeting, sewed on around the edge of the cake, and trimmed off evenly all around, leaving only the surface to be applied to the integument free. This forms a protection for convenience in handling the electrode, prevents wetting the clothing, and serves, likewise, to keep the cake moist when not in use, which it will do for several days or a week if placed right side down (rubber side up) in a drawer, the bottom of which is covered with rubber cloth or oil silk. When completed the whole covering should be wetted thoroughly and kept so. The covering of absorbent cotton next the clay, serves the double purpose of retaining moisture to keep the clay in a plastic condition, always ready for use, and protects the surface to which it is applied from being soiled. Just enough clay transudes the layers of cotton and gauze to fill all the interstices and favor perfect conduction, though not enough to soil, to any great extent, a surface to which the electrode is applied.

These electrodes may be made of any desired size or shape to suit the convenience or fancy of the user. They are always ready for use, neat, easily handled, and will last for a long time. They can be washed off with soap after being used and put away clean for the next time, and when necessary, the covering can be renewed as well as the layer of absorbent cotton. The rubber back can be kept white and clean by rubbing it off with soap or sapolio occasionally. If they become too soft, they should be left exposed to the air right side up for twenty-four hours. Never try to alter the shape or bend the pad unless it is soft and thoroughly pliable, and it is never fit for use unless in that condition.

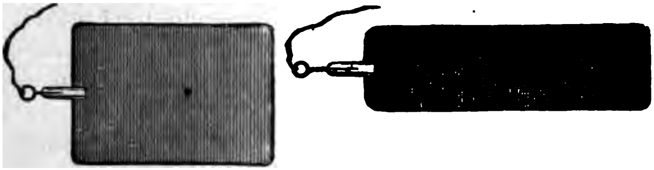

Fig. 35.—Flexible Gauze Electrodes (Woven Wire), Used for Connection with the Clay Electrode.

These woven wire gauze electrodes are of various sizes.

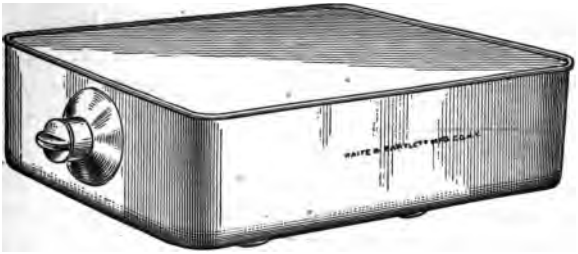

Fig. 36.—Author's Warming Pan for Clay Electrodes.

It is very necessary, both for the comfort of the patient and to facilitate the penetration of the current, to have the external clay electrode, not only thoroughly moistened and pliable, but also, warm, and to secure this the author introduced the electrode warmer shown in the cut, Fig. 36. It consists of a flat jug made of zinc, about the size of a good sized bound book. Its upper flat surface, which is surrounded by an elevated rim, measuring 8 x 12, is left plain—that is not enameled or japaned like the remainder of the surface of the jug—and upon this is placed the pad, clay side down. The pan is 3½ inches deep, is hollow for holding hot water, and rests upon four cork feet attached to the bottom. At one end is a mouth for filling it, closed with a screw stopper protected by a rubber washer. This warming pan, filled with hot water, will retain the heat for several hours. Several clay pads are placed upon this, one upon the other, and are soon thoroughly warmed through. In this way, they are kept ready for use during office hours. In very cold weather, if the water in the jug cools off, it can be readily emptied and refilled. Many ways of keeping these electrodes warm have been tried, but none have been so satisfactory as this. Any device with a flame under the pan drys the clay and renders it brittle and unfit for subsequent use.

Of the other forms of external electrodes it will only be necessary to say a few words. One devised by Dr. Franklin H. Martin resembles an inverted tin basin. Over the bowl is stretched an animal membrane, and its interior is filled with water by means of a tube attached to a faucet or stop cock. The membrane becomes wet and forms the surface of contact with the skin, the connection with the battery being made through the metallic bowl. It is objectionable because unwieldy, and if the membrane becomes perforated the patient will be deluged. Dr. Lapthorn Smith uses the same electrode, but fills the basin with wet clay soft enough to be poured in.

Dr. J. H. Kellogg, of Battle Creek, Mich., has devised a flexible, adhesive electrode for the external surface, to be used dry. It is made by dissolving twenty ounces of the best gelatin in ten ounces of boiling water and adding ten ounces of glycerine and two drams of sodium chloride. The liquid is heated, and ten ounces of finely pulverized gas-carbon (graphite) added and thoroughly mixed.

To make an electrode, a thin layer of the mixture is poured into a shallow tin pan of the size desired for the electrode, the inner surface of which is besmeared with vaseline. Upon this layer is placed a piece of sheet lint of sufficient size to allow the edges to be turned up about one-half inch around the sides of the pan. Upon this is poured more of the mixture, sufficient to saturate and cover the lint; another piece of lint is applied, and the process is repeated until a suitable electrode is cast. Two layers are usually sufficient. A piece of brass-wire cloth, to one corner of which a binding post has been attached, is next applied, and over this more of the mixture, and then another piece of lint. The wire cloth and the last layer of lint may be a trifle smaller than it is desired to have the electrode. Lastly, the upturned edges of the first layer of lint are folded over the back of the electrode, and a sufficient quantity of the mixture applied to hold them in place. When the electrode is cold and sufficiently hardened it is carefully removed from the mold. If the surface of the electrode is not perfectly smooth, or become roughened by use, it may be polished with a hot spatula; if the electrode becomes cracked or its surface very irregular, it may easily be repaired by applying a little of the hot gelatin mixture and smoothing with a spatula. This electrode is light, clean, adhesive, a good conductor of electricity and durable.

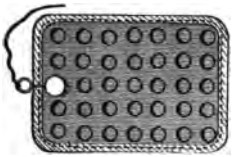

Fig. 87.—George J. Englemann's Punk Electrode.

The punk electrode devised by Englemann is one of the best, but it is difficult, even impossible, to obtain the punk of uniform thickness, and the surface to which it is applied will be burned in spots where it is thinnest. He uses as a plate perforated sheet lead, which would seem to be easily moulded to irregular surfaces, but in fact it becomes wrinkled and so uneven that a very imperfect contact is possible at best. The same plate has been used covered with chamois skin, but the protection is not sufficient for any but mild currents. Massey prefers a flat coil of copper wire covered with a thick layer of absorbent cotton held in place by small rubber bands; but this electrode can only be used comfortably with mild currents, and must require constant renewal of the cotton to keep it fresh and clean, as it cannot be washed. The sponge electrode has been very properly done away with, being unclean and expensive. For ordinary external application with hand electrodes, Piffard has suggested absorbent cotton covered with a layer of gauze and retained in place by a spring band of hard rubber around the rim of specially prepared handles; and he very properly suggests that it should be prepared fresh and clean for every patient. For the same purpose, the author has used the combined dressing consisting of a thick layer of absorbent cotton with gauze on either side, which is more convenient. A circular piece of the desired size is cut off and applied to an electrode handle, being held in place by a rubber band or ring.

For gynæcological work the clay electrode described above is unquestionably the most desirable and convenient, and can be made in any size from the small hand electrode to the abdominal pad. A very convenient size for many purposes is 4 × 6 inches which can be used with a current of fifty milliamperes or less and can be easily slipped under the clothing, necessitating very little inconvenience. It is important to know that with the use of stronger currents the size of the external electrode must be increased, and perfect contact with the integument must be secured in order to make them bearable, besides less battery power will be required to obtain the same strength of current with large than with small electrodes. In order to distribute the action on the integument the author has often made use of a bifurcated conducting cord and applied one electrode to the back over the sacrum and one to the abdomen, both being connected with the same pole. It has been suggested to make the external electrode in the form of a belt encircling the body, which would be a good idea for a sensitive skin, when localization of the interpolar action is not necessary. All external electrodes should be applied thoroughly wet.*

The Vaginal Electrode.—Any electrode whether covered or not when used upon a mucous or moist surface, must be composed of some material not acted upon by acids, if the positive pole is to be connected with it. The oxygen and acids which collect at that pole in the decomposition induced by the current, causes all metals except platinum and gold to be corroded. The author introduced some three years ago, a ball eloctrode made of gas carbon (see Fig. 38) for use in the vagina, designed particularly to be used with the positive pole, but it can likewise be used with the negative, so that the usual metallic ball is unnecessary except for the convenience of faradic applications. For ordinary applications of moderate strength of from ten to twenty milliamperes it may be covered with absorbent cotton for protection, but for stronger currents he advised a protective covering of clay. So far as he knows, he was the first to introduce and use the carbon ball with clay covering, though it has been incorrectly claimed by another writer, without reference to its originator. As shown in the figure, it is as it was presented to the N. Y. Academy of Medicine in 1888. The carbon ball is about the size of an ordinary round vest button fastened on an insulated shaft and handle. It is surrounded by a lump of plastic clay making it the size

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*Dr. Massey has suggested soaping the surface of the external electrode to soften the skin, diminish its resistance, and lessen the irritation produced by strong currents. This will be very seldom required if a properly constructed clay electrode is employed. Where the skin is found to be unusually oily, offering unusual resistance, it should be washed off with alcohol or ether before applying the electrode.

Dr. R. J. Nunn of Savannah, Ga., has suggested placing a piece of wet chamois skin next to the skin, and between it and the electrode for the same purpose. He claims that the most intense currents can be administered in this manner without the least unpleasant effect upon the integument.

Fig. 38 — AUTHOR'S CARBON BALL CLAY COVERED ELECTRODE.

of a large marble; a very thin layer of absorbent cotton is twisted around it and a piece of absorbent gauze for a cover to hold the clay in place, is put on over all and retained by a rubber band around the insulated shaft close to the ball. When it is to be used an additional piece of absorbent cotton is twisted around it and moistened. After it has been used once, this outer layer of cotton is removed, the electrode is washed and a fresh piece is applied for the next patient. The first layer of cotton under the gauze covering, keeps the clay moist and prevents it from oozing through the gauze when it becomes very soft. The clay should be renewed often if the electrode is used very much, since it may become saturated with septic material and acids. To avoid irritation when the positive pole is used the author suggested dipping the electrode in a solution of bicarbonate of soda previous to introducing it, to neutralize acids which collect at that pole. Later he found that coating its surface with egg albumen afforded greater protection. It protects by receiving the action instead of the tissue with which the electrode is in contact. Massey suggested the use of soap for the same purpose. Though good, it is not equal to either the solution of soda or the egg albumen. The author has often used 100 milliamperes with the positive pole for five minutes with this electrode without irritating the vaginal surface, and as much as 200 milliamperes with the negative pole.

This is not often necessary but goes to show how much protection is afforded by this covering of clay. He has had it in use now for more than three years and is satisfied that it is the only electrode that should be used in the vagina with the galvanic current.

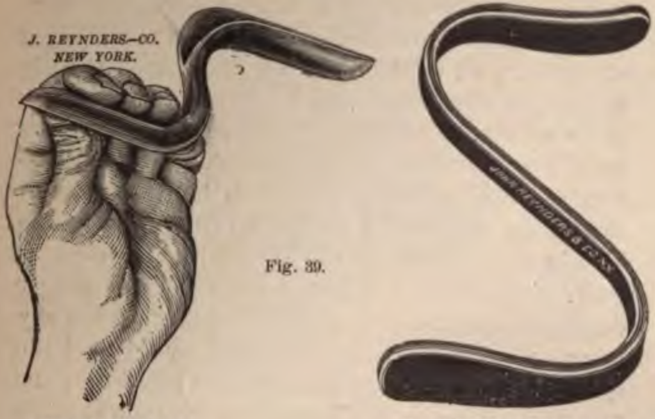
J. REYNDERS—CO.
NEW YORK.

Fig. 39.

AUTHOR'S SPECULUM.

THE ELEVATOR FOR THE ANTERIOR VAGINAL WALL.

To facilitate the induction of ball electrodes when the ostium vaginæ is narrow, the author introduced the speculum shown in the cut Fig. 39, which consists of two Sims' blades joined in opposite directions by a short shank which allows it to be used in either the dorsal or lateral position of the patient. The ball slips along in the groove in the blade which is removed when the electrode is once inside the vagina. The position of the ball is adjusted by means of the index finger introduced along the shaft of the electrode after withdrawing the speculum. Usually the electrode can be removed from the vagina with the assistance of the finger but when this is difficult or causes inconvenience to the patient, the speculum is re-introduced and the ball withdrawn along the groove, while the perineum is retracted slightly by traction downwards and backwards upon the free blade of the speculum. This speculum has been found so convenient for all gynæcological manipulations where a speculum is required, that it has almost completely superseded all other instruments of the kind in office work. It can be held by the nurse as easily as the Sims', and can be managed with greater ease and convenience by the operator alone than any other speculum. Being small and occupying little space, it can be carried handily from place to place even in the hip pocket. To hold the instrument in the vagina for retracting the perineum so it will not slip out, the direction of the force to be applied must be borne in mind. It must be made backwards and inwards in a direction parallel to the internal blade, the beak of which must be inserted behind the cervix. The thumb occupying the position shown in the cut acts as a fulcrum, and directs the beak of the inserted blade towards the sacrum.

An elevator for lifting the anterior vaginal wall, when it is desired to expose the cervix to view in the

dorsal posture, is furnished with the speculum. It is hooked under the pubes and held by an assistant or the patient herself.

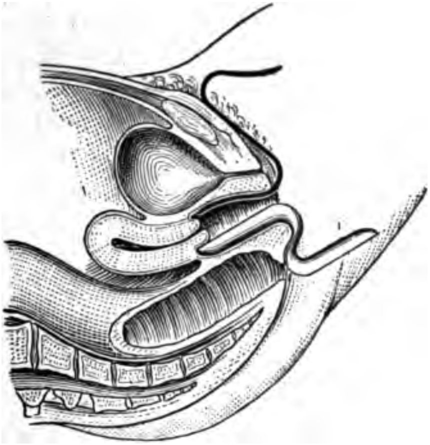

Fig. 40.—This cut shows the Speculum and Elevator in position.

This speculum can be insulated by a covering of hard rubber, by any dentist. The rubber is applied evenly while in a soft state, surrounded by a plaster of Paris mould and vulcanized.

SPECIAL FORMS OF ELECTRODES FOR GYNÆCOLOGICAL WORK.

The Dilating Negative Electrode for the Cervix — This electrode, shown in the figure, was designed for dilating the cervical canal but may be used for any negative application to the whole uterine canal where a bare electrode is required, if the canal does not measure more than two and a half inches.

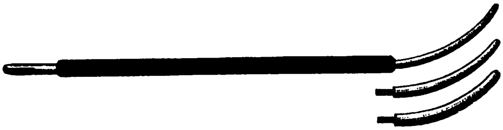

Fig. 41.—AUTHOR'S INTRA-UTERINE NEGATIVE ELECTRODE, 5-STEMS.

It has five nickel-plated copper tips, of different sizes, which screw into an insulated shaft or handle. These tips are two and a quarter inches long, conical at the point, and correspond with the numbers 9, 11, 13, 15 and 17 of the French scale, the smallest being about the size of the ordinary uterine sound. Being made of copper, they can be bent to suit the curve of the canal. There is a shoulder at the junction of the metallic tips with the shaft, which prevents contact of the electrode with the fundus by limiting the penetration of the electrode beyond that point. They were designed to take the place of the bulb electrode introduced by Dr. Henry D. Fry, of Washington D. C., for the same purpose, (see Fig. 53) and are preferred because they are more easily introduced, and the current can be applied to the whole length of the canal after the constriction has been passed. Until the constriction yields, the action of the current will be greatest (where it is necessary) at the point where the firmest pressure forms the best contact, and after relaxation occurs it will be distributed equally throughout the length of the canal, diffusing the local action. These electrodes should be used only with the negative pole since the metal is corroded by the action of the positive pole, which would destroy the tip and provoke undesirable irritation of the endometrium.

Any electrode which is corroded by the action of the positive pole should never be used with that pole either in the uterus or vagina.

Electrodes for Positive Pole. — These should be made of platinum, gold or carbon, which are not affected by the action of the acids, oxygen, and chlorine with the heat generated at the positive pole. The expense of the platinum which is really the only one of the two metals named not subject to action (gold being consumed after a time) has led to many attempts to substitute something cheaper, but with little success. Platinum is the only reliable and lasting material for the positive electrode, and is really cheaper in the end, being everlasting. Aluminium is not satisfactory.

The Apostoli platinum sound, shown in the cut, is a rod of solid platinum twelve inches long, the size of the ordinary copper uterine sound. This slides through the center of an ebony handle, and can be set at any length by a thumb screw in the handle. The insulation is furnished by a celluloid sheath or tube which slides over the exposed portion of the sound outside of the handle. There are several lengths of the sheath or insulating tube which, with the thumb screw in the handle, allows any desired length of the sound to be exposed for action. The object of this arrangement is to have in one instrument an electrode for application to the uterine canal of any length from two and a half inches to eight or nine inches. Thus the same instrument can be used for applications to a moderately hypertrophied uterus, as well as to the enormously enlarged fibroid uterus, and the entire length of the canal can be submitted to the action of the current in each instance. It can, of course, be used with the negative pole also. Apostoli believes that often when the uterus is diseased and requires this treatment, the whole organ should be submitted to its action, particularly the endometrium from the external os to fundus. Besides a greater length and extent of surfaces is exposed to contact

Fig. 42. Dr. Apostoli's Intra-uterine Electrode of Platinum.

with the tissues, and, as is sometimes desirable, a stronger current can be employed with less local caustic action. For controlling uterine hæmorrhage he usually submits only the uterine cavity to the action of the current, using a carbon electrode, to be described further on.

Fig. 43 shows a platinum electrode possessing all the advantages of Apostoli's and less than one-third the cost, because there is very much less platinum, and the handle is simple in design. The shaft and handle is that of an ordinary copper uterine sound, to the extremity of which is attached either five or seven inches of platinum which is continuous with the shaft. It is insulated with a tube of catheter material, tipped at each end with hard rubber, which being flexible may be easily removed for cleaning. A movable slide with set-screw on the shaft, adjusts this insulating sheath so as to expose the desired surface of platinum

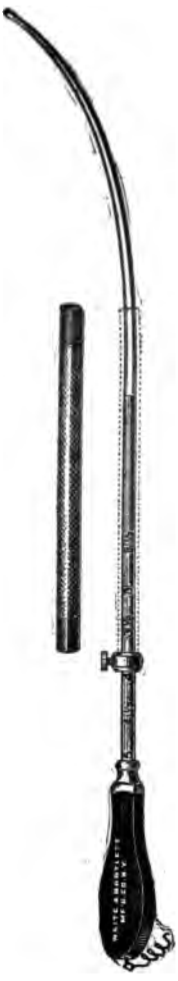

Fig. 43.—Author's Platinum Sound Electrode with Flexible Sheath Arranged for Measuring the Length of the Uterine Canal.

beyond. The sheath is so proportioned that the distance from its distal end to the extremity of the electrode, corresponds with the measure recorded on the shaft at a level with the adjusting slide, making the electrode useful for measuring the length of the uterine canal, which can be read off on the shaft outside.

Objection has been made to the platinum sound because it is rigid and cannot be readily bent. Apostoli introduces it straight along the index finger as a guide and does it very dexterously. It can be more readily introduced, however, if it is slightly curved.

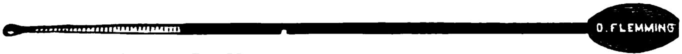

Fig. 44. DR. MASSEY'S FLEXIBLE PLATINUM ELECTRODE.

Flexible platinum electrodes made of spiral wire have been devised by Martin and Massey, but the length of the exposed surface is limited, and they do not answer the same purpose as the platinum sound.

Dr. Massey has had the electrode for the positive pole made of a firm copper shaft, to which is attached a tip of platinum two and one-half inches long. This is insulated by a movable hard rubber tube. Dr. W. J. Morton suggested a method of insulating this and other electrodes by heating the metal and rubbing it while hot with a piece of hard rubber (a broken thermometer case will do). The rubber will melt and adhere to the metal, forming when cold a firm and perfect insulation which can be smoothed off and polished. The advantage of this insulation is that it fills up every unevenness of the surface and makes a thoroughly aseptic electrode, and it can be easily removed when desired simply by passing it through the flame of a spirit lamp and wiping it off. Needles for buried puncture can be insulated in the same way.

The author endeavored to overcome the objection to the rigidity of the platinum sound by having it flattened out with the edges well rounded, and in this way it can be made about as flexible—or rather, pliable—as a copper sound. To lessen the expense, a platinum rod of seven or eight inches is attached to a rigid steel shaft, which would be suitable for most cases, even of quite large fibroids, and the expense is reduced about one-third. It makes a very satisfactory and comparatively inexpensive electrode. See Fig. 45. The point is made without a bulb when it is to be used as an applicator wrapped with cotton.

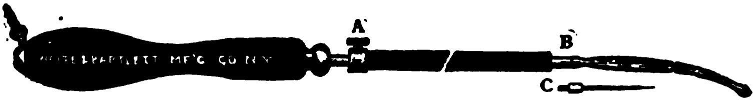

Fig. 45.—Author's Modified Platinum Uterine Electrode and Applicator with Universal Handle.
C is a puncture needle for attaching to the same handle.

The Apostoli Carbon Electrode for Sectional Cauterization of the Uterine Cavity.—This electrode was devised and is used for more readily controlling hæmorrhage from the uterus than is possible with the platinum sound. As shown in the cut, Fig. 46, it is a straight insulated shaft fifteen inches long, terminating in a tip of carbon one inch in length. These tips are of seven different sizes, and are fixed permanently on the shaft or handle. The shaft is marked with notches equal distances apart, representing the length of the carbon tip. In using them, one is selected the carbon tip of which will fit the uterine cavity snugly, forming perfect contact with that portion of the endometrium included, and it is passed to the fundus along the index finger as a guide, noting the location of the nearest notch (upon the shaft) to the external os. It is to be held quietly in position, with the requisite current strength (galvanism) turned on, for from three to five minutes, when it is withdrawn until another notch presents the same location at the external os, thus exposing a fresh section of the endometrium to contact with the exposed carbon tip. This is done usually without turning off the current. After cauterizing the second section it is again withdrawn in like manner, and so on until the internal os is reached, and the whole of the uterine cavity has been submitted to the action of the current.

The platinum sound is limited in its use, for controlling uterine hæmorrhage, to conditions where the uterine canal and cavity is narrow, allowing fair contact with the endometrium, since contact is necessary for effective cauterization; but, where the cavity is large and dilated, the sound will prove ineffective as an electrode for the control of hæmorrhage, and it becomes necessary to resort to sectional cauterization with the carbon electrode. Hence, it will be understood that the main advantage of the carbon electrode is that its diameter allows better contact with the surface to be acted upon, and the concentration of the local action of the current upon a limited surface makes it more decided with the same strength of current than if spread over the whole area at once.

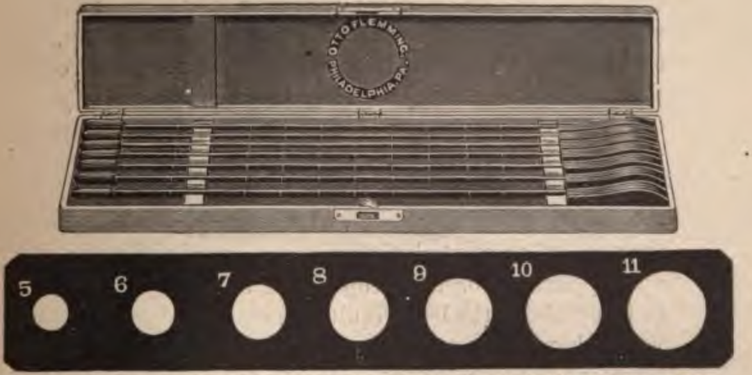

Fig. 46.—Dr. Apostoli's Carbon Electrodes for Sectional Cauterization.

It may be sometimes difficult to introduce the proper size of this electrode through the cervical canal, which may be narrow when the cavity is much dilated, and, though it is not done by Apostoli, it will be advisable to dilate the cervix gently with the steel dilator when necessary for this purpose.

Steel Electrodes Specially Prepared to Resist the Action at the Positive Pole.—To lessen the expense of the electrical outfit, the author introduced to the profession about three years ago, a number of electrodes made of steel which had been submitted to a process (unknown to him) that prevented oxidation, and resisted for a time the usual action of the positive pole. This he was enabled to do through the courtesy of a patient, the owner of this process, who kindly aided him in every possible manner to have them perfect. Unfortunately, the short-sighted policy of the different manufacturers, who were approached on the subject, prevented the construction of the necessary apparatus for the proper treatment of the steel to bring about the best result. In consequence, those which have been sent out, though correct in design, were but imperfectly submitted to the process necessary to make them resist oxidation or the action of the current, and they have given dissatisfaction. They will, however, in their present imperfect state, answer for mild currents, and, being inexpensive and removable from the shaft to which they are attached by a screw, they can be readily replaced when they begin to show action. It is possible, with a little outlay, which could be shared by all the manufacturers of electrical instruments for medical purposes, if they would combine, to perfect these electrodes so they would withstand even strong currents for some time, and their expense would be insignificant as compared with the instruments now in use for the same purpose.

The cut, Fig. 47, shows the electrodes made of this material. They have been made in imitation of the carbon electrode of Apostoli, referred to above for sectional cauterization. A sound electrode for applications to the whole canal is also made of this material. There are two tips, one, two and a half inches long and another, three and a half, screwed on an insulated shaft of the same size as that used for the others. In the set there should be two handles or shafts, one for the longer tips and one for those of an inch in length for sectional cauterization. These latter are made in eight different sizes from eleven to twenty-nine of the French scale, screwed upon a neat ebony plate to

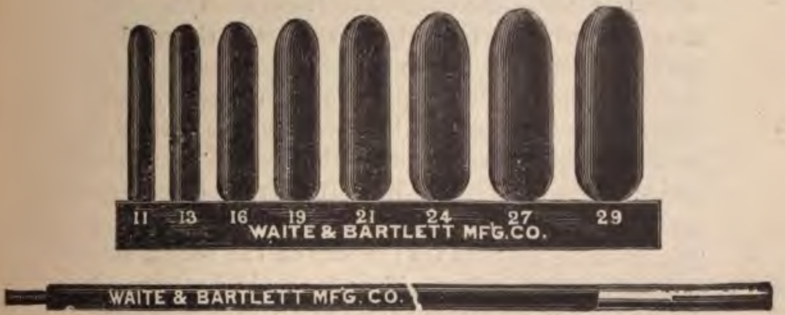

Fig. 47.—Author's Steel Prepared Electrode for Sectional Cauterization.

be kept convenient for use. The shaft to which they are to be attached can be curved slightly if desired by first oiling and then heating it gently over a spirit lamp.

The object of having the carbon permanently attached to the shaft is to avoid the possibility of its becoming loosened and left in the uterine cavity, whence it would be difficult to remove. This is not necessary with the steel tips because the thread will hold them firmly, and no such accident need be feared. These electrodes have been recently produced in block tin which is acted upon very slowly; and, as no injurious decomposition results from the action upon this metal, it is free from objections upon this score. It possesses the advantage of being pliable in the form of tip the size of the sound, but it is quite brittle when cold and should be warmed by dipping in hot water before being bent.

The author has recently had an electrode made of soft iron for use with the positive pole. It can be used for some time without becoming rough, and being inexpensive, is readily replaced. It is quite as pliable as the block tin. The only objection so far observed is that the action on the metal causes it to adhere to the surface, preventing ready removal; but this can be overcome by using the negative pole for a few moments after the application, to loosen it.

Puncture Needles For Galvano-Puncture.—These are made of a variety of sizes and shapes, many of them most inappropriate and unsuitable. Those which have heretofore been sold in this country, of the spear and lance pointed variety, were intended for abdominal puncture, and are in no way suitable for puncture after Apostoli's method. They are large and not readily introduced, and have no guide to limit the depth of penetration, which is by no means an unimportant matter. As they are but little used now, it will be unnecessary to describe them further.

The danger of galvano-puncture of fibroids of the uterus has been very much lessened by the adoption of the method of Apostoli,—puncture through the vagina with a filiform needle, the penetration being limited to one or two centimeters. He selects by preference the lateral fornix of the vagina, avoiding the anterior on account of the danger of penetrating the bladder.

The needle as shown in the cut is as he used it until about a year ago. It is a stiff rod of steel made the size of the platinum sound so as to be used in the same handle as the platinum sound electrode, terminating in a fine needle forged upon the extremity, about two centimeters in length, finely pointed with three edged point. The same insulating tube of celluloid used for the

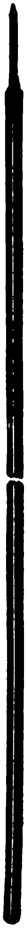

Fig. 48.—Apostoli's Puncture Needle to be used with the same Handle as the Platinum Sound.

sound is employed for the same purpose for the needle. This is placed over the needle shaft, and by means of the thumb screw in the handle the needle is fixed so as to expose only the desired length of point beyond, usually about one centimeter. The insulating tube is then removed and passed along the index finger in the vagina as a guide to and against a point previously decided upon. It is held firmly in position between the thumb and middle finger of the same hand, while with the other the needle fixed in the handle is introduced through it (the tube). When the needle point touches the vaginal surface, at the point occupied by the end of the tube, a quick movement and firm pressure will cause it to enter easily and with little or no discomfort to the patient. In withdrawing the needle after the application of the current, the tube is pressed firmly against the vaginal surface touched by its end, and the needle is loosened by a slight rotary motion of the handle. Puncture with this needle allows the local action of the current to take place along the whole track penetrated by the needle, from the vaginal surface where it enters to its point, the object being to leave behind an opening or drainage track for subsequent suppuration should it occur. This, however, seldom or never results when strict antiseptic precautions have been taken.

The needles used by Apostoli are made of steel and are destroyed when used for positive puncture. The author has had the filiform needle point (which is only about two centimeters long) made of platinum and attached to the steel rod. With ordinary care the point can be kept sharp.

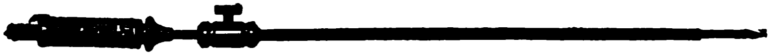

Fig. 49.—Author's Canula Electrode with Silver Canula and Steel Trocar and Adjustable Sheath for Puncture of Hydro-Salpinx.

Fig. 50.—Author's Platinum Spear-pointed Puncture Needle, Rubber-covered Shaft, with Measuring Shield.

For the past year Apostoli has employed a needle made in the same way as described above, but insulated to within a quarter of an inch of the point, so that the local action of the current is confined to the point, the insulation preventing the action along the remainder of the track. This was done because he found there was no necessity for subsequent drainage, and because he ascertained by experiment that much of the effect of the current was due to the gases set free, which by puncture with the other needle, escaped around it into the vagina. With the insulated needle they are confined and allowed to penetrate the tissues in the vicinity of the needle point. The exposed point of this needle is platinum.

The author has made a modification of this needle, see Fig. 51. The point is made of an alloy of platinum and iridium which is harder than platinum

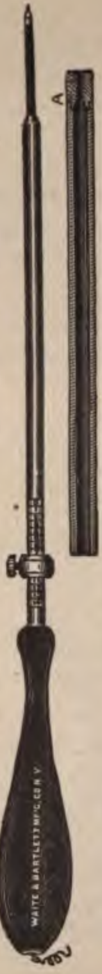

Fig. 51.—Author's Insulated Puncture Needle, with Shield.

alone, and more durable. A cutting point made of this alloy will retain its edge much longer than platinum, which soon becomes dulled. But a filiform needle of either the platinum or alloy has so little rigidity that it is extremely apt to bend under use and become deflected from its course, and to avoid this, the celluloid or hard rubber tube for insulating the shaft and limiting penetration is made as shown in the cut, the end of it being closed, all but a very small opening in the center large enough to admit the needle, see A. This forms a support for the needle of a quarter of an inch at the lower extremity of the tube, up to the point of contact with the vaginal surface, which is sufficient to prevent bending. For greater convenience, the steel rod or shaft has been fixed in a handle permanently, and this arrangement necessitates a sliding nut for setting the needle for any desired degree of penetration. A separation is made in the sheath at A. for detaching the end and cleaning the interior.

Fig. 52 represents a platinum canula with steel trocar devised by the author for aspirating hydro- and pyo-salpinx and small cysts by the vagina, when accessible through that channel. After the fluid is withdrawn the galvanic current is turned on through the canula as an electrode, the positive pole being used in pyo-salpinx and the negative pole in hydro-salpinx. The instrument consists of a platinum canula the size of a No. 4 catheter (French) about seven inches long, with a sliding covering of hard rubber for insulation and thumb-screw attachment for fixing the depth of penetration. A two-way stop-cock has been placed on the handle, so as to allow the aspirated cavity to be washed out when necessary

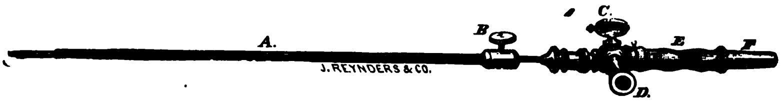

Fig. 52.—Author's Platinum Canula Electrode.

The cut shows the author's platinum canula electrode (No. 4, French catheter scale) for the galvano-tapping of pyo-salpinx through the vagina. The shaft is covered with an adjustable sheath (*A*) of hard rubber for insulation. This may be fixed at any point by the screw *B* and the degree of penetration limited. At *C* there is a two-way stop-cock, and at *D*, a connection for an irrigator, as well as a socket for connecting with the battery. When the trocar *F* is withdrawn, an aspirator may be attached to the rubber tubing *E*, and after the pus has been drawn off, by a quarter turn of the stop-cock *C* the cavity may be flushed with an antiseptic solution passing in at *D* through the canula. By turning the stop-cock straight again the fluid is allowed to escape through the tubing *E* into the aspirator bottle. Care must be observed not to over-distend the Fallopian tube, the walls of which have been much weakened in some cases. That I may not be misunderstood, I will say that I limit the degree of penetration usually to one centimeter, and deem the procedure appropriate only when the tube is close to the vaginal wall, full and tense, demanding immediate interference.

before applying the current. The attachment for the connecting wire with the battery is at D. For a further description of the method of using this instrument see treatment of pyo-salpinx.

A very good negative electrode, for many purposes, may be improvised from the ordinary copper uterine sound by placing over it for insulation a piece of catheter or a celluloid or hard rubber tube, and having a hole drilled in the metallic part of the handle for attaching the connecting wire with the battery. After it has been introduced to the fundus the insulating tube should be pushed up against the cervix, so as to protect the vaginal surface; and this insulating slide should be long enough to project out beyond the vulva. If a small portion of the sound near the handle is exposed it is of no consequence, if care is taken to prevent contact with the integument of the thighs.

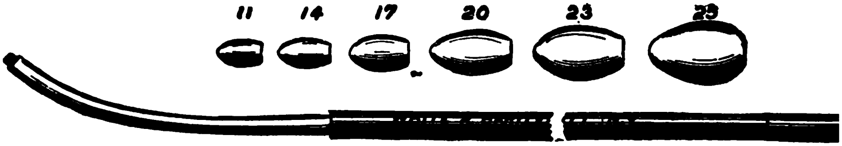

Fig. 53.—Dr. Fry's Intra-uterine Electrode for Stenosis.

A very useful electrode has been devised by Dr. H. D. Fry, of Washington, after the plan of the *bougie à boule* for the male urethra (see Fig. 53), having the shaft insulated and only the bulb exposed. The bulbs are of different sizes and screw on the shaft. Many prefer to use this electrode for stenosis, as recommended by the originator, claiming that by its use the action of the current is confined to the location of the bulb where it is demanded, while the unconstricted portion of the canal remains unaffected. The author prefers to use the electrode shown in Fig. 41, which enters more readily and insures a more perfect action upon the constricted portion of the canal while the electrode is in use. It is certain that there will be more action at the point of constriction, where the pressure forms better contact, and that the action will be little or nothing in the unconstricted portion, where contact is imperfect. And this contact at the point of constriction is maintained all the while the electrode is in position until it reaches the fundus, or until its complete introduction is accomplished, while with the bulb electrode the contact is only maintained while the bulb is passing the constriction, and ceases as soon as the constriction is passed. While this may be a desirable end in the treatment of urethral stricture, where the principle was first applied, it does not

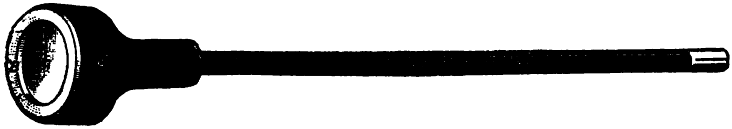

Fig. 54.—Dr. Hunter McGuire's Electrode for Cataphoresis.

Absorbent cotton or blotting paper is placed in the cup at A and saturated with tincture of iodine. The electrode is made both straight and curved, and it can be used either in the vagina or on the external surface of the body.

wholly meet the requirements of softening the dense structure in cervical stenosis. The surfaces and structures are in no way analogous, and consequently are not subservient to the same methods of treatment.

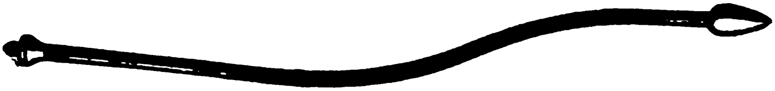

Fig. 55.—Rectal Electrode.

Special Electrodes for the Faradic Current.—Any of the above electrodes may be used with the faradic current, except the puncture needle and aspirating canula. The clay covered ball vaginal electrode may be used, but there is usually too much resistance in the covering, and a bare metallic ball is preferable. For the external electrode, a metallic plate or the woven wire gauze electrode covered with clean sponge or absorbent cotton is often to be preferred to the clay pad, for the same reason. But it is a point well worth knowing that when it is desired to employ a very strong induced current in this manner, with one pole internally (in the vagina or uterus) and the other externally, that a stronger current can be used, and it will produce less discomfort if the external electrode is large and spread over a large area of integument, which is accomplished by using the clay pad employed for the galvanic current. In this way, it is often possible to use an intensity of current nearly equal to that allowed by the bipolar method of Apostoli. It was in order to make a very intense current bearable that Apostoli was induced to employ the bipolar method, as well as for the purpose of concentrating the action. This method consists in employing an electrode with both poles arranged on one shaft about an inch apart, connected with separate wires insulated from each other, and extending through the center of the shaft to a binding post or slot connection for wires from the battery, one for each terminal wire or pole.

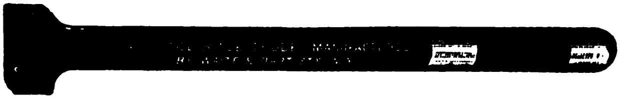

Fig. 56.

Apostoli's Bipolar Vaginal Electrode for the Faradic Current.

Fig. 56 shows the bipolar vaginal electrode which is made in two sizes. One smaller than the other for virgins. In using this electrode care must be taken to keep it well within the vagina, so that the metal surface will not come in contact with the sensitive tissues at the vulva. A very intense current can be endured within the vagina with no discomfort, but a very mild current in contact with the orifice will cause the patient to cry out.

Fig. 57 shows the bipolar uterine electrode for use within the uterine cavity. It is very essential that both metallic surfaces should be completely within the cavity during the application. There the current will be endured with almost as little discomfort as in the vagina, but the cervical canal, and particularly the internal os is very sensitive to the current, hence it is important to be sure that both metallic surfaces are introduced beyond that point before the current is turned on; and the electrodes should never be allowed to slip down. Many of the bipolar uterine electrodes made and sold in this country are straight, rigid and entirely too large, being made with utter disregard for the original models and the diameter of the uterine canal. The insulation is of hard rubber and unyielding, consequently they cannot be introduced without previous dilatation or without inflicting serious damage. There are two sizes of the original electrode, as made by Gaiffe, of Paris, the smaller being no larger than the uterine sound, the other being a trifle larger; and they are flexible, the insulation being made of a form of black catheter material similar to the material of which French bougies are made.

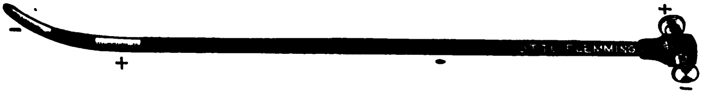

Fig. 57.
APOSTOLI'S BIPOLAR INTRA-UTERINE ELECTRODE FOR FARADIC CURRENT

The author does not regard as practical the adjustable bipolar electrode introduced by a recent writer, particularly the one intended for the uterus. In order to render the outer surface movable over the shaft to which the inner is attached, it is necessarily so large, that it will be impossible to pass it through the internal os or the canal without previous dilatation, and this would be very undesirable in any condition requiring bipolar faradization of the uterus, except perhaps subinvolution.

A word about electrode connections. Although the binding post attachment has been pictured in some of the cuts it was not done by the author's consent, and any electrode so constructed is condemned by him. They are in every way the most clumsy, inconvenient and awkward connections ever devised and should never be placed upon an electrode. The spring slot or slit connection, sunken in the handle on a level with the surface is neat and convenient, and any rheophore tip will fit it or can be made to fit it, if too large, by filing down the point of the tip. The same connection is likewise much more suitable for small portable batteries than the clumsy binding posts ordinarily used.

Connecting Cords or Rheophores.—These should be made of several strands of fine copper wire covered with rubber and silk braid, with a soldered connection to the tip, never by simply winding the wire around the tip. This form of cord should be used for both the galvanic and faradic currents. The tinsel cord ordinarily furnished with faradic batteries should never be used under any circumstances. They should never be used for the galvanic current and are unreliable and unsuitable for the faradic current, particularly if there is no measuring instrument employed in the circuit to indicate that there is a current circulating between the terminals, as the sensations of the patient are not to be relied upon, and these cords are very defective. It is true that when new and perfect they are a good conductor for the faradic current, but they are never certainly perfect, and are very easily rendered worthless. If they once get wet they are unfit for future use.

Enough has been written descriptive of the different forms of electrical apparatus for gynæcological use. What the physician now needs most is a detailed description of how to apply electricity to the treatment of disease. Most works upon this subject are strangely vague upon this most important question (technique), the information to be derived from them being of the most meagre sort. Is it because authors are deficient upon this point, or because they do not recognize how important it is to the average worker in electricity?

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